LAKE ONTARIO FISHERIES UNIT

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LAKE ONTARIO FISHERIES UNIT

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Lake Ontario Fisheries Unit
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1989 ANNUAL REPORT
LAKE ONTARIO FISHERIES UNIT

TABLE OF CONTENTS

Lake Ontario Fisheries Unit 1989 Program Summary 1-1

Walleye Populations In Eastern Lake Ontario and the Bay of Quinte, 1989 2-1

The Relationship Between Walleye Populations and Index Gill Net Catches in the Bay of Quinte 3-1

Smelt Abundance and Growth in Western Lake Ontario 4-1

Status of Lake Whitefish Populations in Eastern Lake Ontario 5-1

Nearshore Index Gill Nets, 1989 6-1

Survival, Growth, and Distribution of Stocked Lake Trout: Analysis of Canadian Fin Clip Data 7-1

Surveillance Report for: Lake Trout Rehabilitation in Lake Ontario 8-1

Community Oriented Lake Assessment 9-1

Credit River Coho Spawning Run, 1989 10-1

Lake Ontario Stocking and Marking Program for 1989 11-1

Salmonid Angler Survey of the Western and Central Basins of Lake Ontario 12-1

A Model to Relate CREESYS Estimated Fishing Effort to Trailer Counts at Launch Ramps in the Lake Ontario Salmonid Fishery 13-1

Research Project: Fish Community Dynamics of the Outlet Basin of Lake Ontario 14-1

Research Project: Fish Community Studies of the Bay of Quinte 15-1

Research Project: Sampling Variability of the Fish Community of the Outlet Basin of Lake Ontario 16-1

Research Project: Lake Trout Rehabilitation Studies 17-1

Research Project: Stock Identification of Lake Ontario Lake Whitefish 18-1

Research Project: Discriminating Between Rainbow Trout of Native and Hatchery Origin 19-1

Lake Ontario Fisheries Unit
1989 Program Summary

A. Mathers and J. M. Casselman

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Lake Ontario Fisheries Unit, 1989 Annual Report, LOA 90.1 (Chapter 1)

Introduction

Since 1984, LOFU staff have prepared an annual report which summarizes work undertaken during the previous fiscal year (12 month period between April 1 and March 31). Each annual report consists of a compendium of reports on a variety of subjects. They are intended to keep scientists and managers who work on Lake Ontario informed of our activities, and to promote cooperation and interaction by this group. Reports are written to highlight information of interest to Lake Ontario managers; they are not intended to be substitutes for refereed, journal publications. Some projects do not produce immediate results, and some tasks do not require reports. The purpose of this section is to summarize tasks and information not presented elsewhere. This includes:

1. A list of Research activities at LOFU
2. A list of all tasks undertaken including a listing of Assessment programs, projects and project leaders
3. A report on staff at LOFU, building renovations and vessel alterations
4. A report on commercial landings in eastern Lake Ontario
5. A discussion of the the status of the Lake Ontario Fisheries Management Plan

Summary of Research Activities During 1989/90

Four major research projects were conducted during 1989 and are included later in this annual report. These involved (1) fish community dynamics studies of the Outlet Basin of Lake Ontario; (2) fish community studies of the Bay of Quinte; (3) factors affecting lake trout rehabilitation; and (4) sampling variability. Also included in this annual report are descriptions of two short-term projects involving the stock identification of lake whitefish and rainbow trout in Lake Ontario. These projects were initiated at the request of Fisheries Assessment and Management. The following is a summary of ongoing research activities not included elsewhere.

(a) Age-Growth and Environmental Studies

The Age-Growth and Environmental Studies unit (A.G.E.S.) of the Research Section, is now a component of Research at the Glenora Fisheries Station with a provincial mandate, has set up its age-growth laboratory in the facilities at the station. Field studies of A.G.E.S. research until recently have been conducted in lakes of the Haliburton Highlands of Ontario.

The field collection phases of these studies are complete, and analyses are under way and will be reported elsewhere. Some of the age-growth research is now being directed specifically at problems associated with Lake Ontario fishes. They generally involve validating, refining, and mechanizing age determination and growth estimation. One of the major initiatives of this research will be directed towards providing validated year-class strength determinations for current and historic fish community dynamics studies of the Outlet Basin and the Bay of Quinte. This will mean that the effects of environmental factors and species interactions can be more precisely quantified and predicted.

As part of a systematic approach towards solving age-growth determination problems, a computer program is being developed that interfaces with a digitizer and permits interpretation of the checks and zones in the calcified tissue of fish to be quantified. This technology involves digitizing and ranking the extent and location of checks and zones during routine interpretation. This computerized system mechanizes the data-extraction procedure and permanently records all of the information collected during routine age and growth interpretations. This scale check quantification technique and associated software is still developmental but is currently being tested in two research projects supported by Canada-Ontario Agreement (COA) funding. One program involves the extraction and study of the past 30 years of growth history recorded in the scales of white perch that have been collected from the Bay of Quinte and that are in the scale archive at Glenora. The technique is also being used to test and develop valid age-interpretation procedures for the scales of lake whitefish from the Outlet Basin series and to study the factors affecting growth and production of lake whitefish in the Outlet Basin and Bay of Quinte over the past 28 years.

(b) Studies of Environmentally Sustainable Development Studies

Jack Christie continued his research at the station on economic development and sustainable fisheries. These multidisciplinary, multiagency studies involve the Rawson Academy, the federal government, and Queen's University. He has helped establish a Sustainable Fisheries Network. The specifics of his work in this field of fisheries science have been variously reported and are not included here.

(c) Research Associations

In the spring of 1989, Dr. Mark Ridgway, who is a Research Scientist associated with the Lake Ontario Unit, transferred to the University of Toronto. He will continue his smallmouth bass research in a program conducted jointly by the University of Toronto and the Ministry of Natural Resources at the Harkness Laboratory. Dr. Ridgway has collaborated with Dr. Donal Hurley, of LOFU, on several research projects including their study of alewife community dynamics in the Bay of Quinte and their continuing work on a gillnet-selectivity model for white perch in the Bay of Quinte.

Dr. Casselman, a conjunct professor at Trent University, continues as an advisor to a CIDA limnology project that jointly involves Waterloo University and Addis Ababa University in Ethiopia. In this capacity, he acts as a committee advisor to two M.Sc. students working on the fisheries of the Rift Valley lakes in Ethiopia.

(d) Cooperative Research Involving University Graduate Student Programs

During the past year, four graduate students from Ontario universities have conducted parts of their research programs under the auspices of the Unit and have used the facilities at the station. Cheryl Podemski, working on an M.Sc. degree with Dr. Roger Green of the University of Western Ontario, is studying production and biomass of the benthos, especially clams, at various locations along the trophic gradient down the Bay of Quinte. This work will examine the correlation between benthic invertebrate and fish production. This is a very timely study, since it precedes the anticipated invasion by zebra mussel of the Bay of Quinte.

Paul Anderson, working on an M.Sc. degree with Dr. Tom Whillans of Trent University, is studying habitat utilization by juvenile northern pike in the wetlands along the north shore of Lake Ontario and the Bay of Quinte. He has used the aquatic facilities at the station to conduct controlled laboratory studies of pike preferences in relation to submerged aquatic plant species and densities.

Kevin Reid, another graduate student of Dr. Whillans, who has studied pike spawning and nursery requirements in a small kettle lake undergoing rapid urban development, worked in the age-growth laboratory with Dr. Casselman, a member of his M.Sc. advisory committee and a conjunct professor at Trent University . His thesis involves relating northern pike population dynamics and year-class strength in relation to spawning and recruitment.

Yosef Tekla-Giorgis, a CIDA-sponsored student enrolled in an M.Sc. program at Waterloo University supervised by Dr. Casselman, used the age-growth facilities to interpret and analyze age and growth of Tilapia from Lake Awassa, a lake in the Rift Valley of Ethiopia. This study has direct applications to Ontario fisheries problems, since it was designed to determine if stunting limits the growth and production of fish. This study has developed accurate age determination and growth estimation techniques for slow-growing fish. This is a universally important fisheries problem, and the results of the study will greatly improve our understanding of how environmental factors affect the growth of fish calcified tissue and its use in accurate age interpretation. This research study is especially challenging since it involves tropical conditions, high water temperatures, and two annual growing seasons, spawning seasons, and major growth periods.

(e) OMNR Review of Research Needs for Lake Ontario for the 1990's

During the past year, the Lake Ontario Research Unit has conducted an extensive review of research needs for Lake Ontario fisheries for the 1990s. This has involved input from all OMNR scientists conducting research on Lake Ontario, Fisheries Assessment Unit personnel, and managers from the districts and regions involved with the lake. The research needs have been reviewed in the context of OMNR research on the Great Lakes so that an integrated, overall Great Lakes research plan can be prepared. The Lake Ontario research needs review is complete and includes a list of priorities; the report is pending and will be submitted to the Research Manager of the Research Section for review and consideration. The review considers a transfer of the routine assessment responsibilities for the Outlet Basin and Bay of Quinte from Research to the Assessment component of the Unit. Although Research will continue to have an ongoing interest in and will continue to analyze these research index series, in the future, Research will emphasize more short-term, problem-process-oriented studies. Preference will be given to research problems that not only have a direct application to Lake Ontario but also make a provincial contribution that is of general interest to the primary scientific literature.

During 1989, research initiatives proposed for the Bay of Quinte have drawn on this specific review of research needs. Dr. Hurley has prepared a set of research proposals as part of the Remedial-Action Plan (RAP) for the Bay of Quinte. One specific project emphasizes the need for quantitative studies of the community dynamics and production of small, young fish for both the pelagic and inshore regions of the Bay. Studies of small fish in the Bay of Quinte are badly needed. A detailed set of research proposals has been prepared to address the potential problems associated with the establishment of zebra mussel in the Bay of Quinte. These proposals deal specifically with the impact of zebra mussel on the substrate used by spawning walleye and with quantifying their effects on primary production and the transfer of this impact through the food chain eventually resulting in decreased fish production.

(f) Bay of Quinte Remedial Action Plan

Dr. Hurley continued his active involvement with the committee struck to review and implement the remedial action plan for the Bay of Quinte and with the Quinte group who continue to cooperate on ecosystem research on the Bay of Quinte.

(g) Provincial Lake Trout Data Synthesis

Dr. Casselman has completed a study that involves 9% of Ontario lake trout lakes as part of a provincial initiative to synthesize existing lake trout data collected throughout the province. This study involved the analysis and quantification of habitat and environmental factors that affect lake trout recruitment. The study dealt with the effects of loss of deep water nursery habitat and adult suppression on the productivity of native lake trout stocks. This research provided direct evidence that there must be adequate quantities of well-oxygenated, high-quality, deep water nursery habitat for juvenile lake trout if there is to be significant natural recruitment.

(h) Gillnet Standardization

In 1989, an important decision was made concerning the standard experimental gillnet that is used in Lake Ontario. It is becoming increasingly difficult to obtain the multifilament material used to build the experimental gillnets used in the Research index series. A joint decision was made by Assessment and Research groups working on fisheries around Lake Ontario to change from multifilament to monofilament gillnet webbing. This monofilament webbing would become standard for all experimental gillnets. Since present multifilament gillnets are hung with an extremely oval diamond, (web to line ratio 2.5:1) and were originally specially built to the specifications used by commercial fishermen on their 4.5-inch lake whitefish gillnets, it was decided to follow a more normal hanging ratio typically used in experimental gillnets for community indexing (web to line ratio 2:1). Research has agreed to these changes as long as adequate comparative sampling can be done such that the long-term gillnet research series of the Bay of Quinte and the Outlet Basin can be adequately compared and correlations can be developed between these two types of gillnets. As part of this conversion, Research intends to study and compare the sampling characteristics of monofilament and multifilament and the two different hanging ratios in the warmwater fish community of the Bay of Quinte and the coldwater fish community of the Outlet Basin.

Assessment Tasks Undertaken During 1989/90

Seven programs involving 28 projects were conducted during 1989/90. A list of project names and associated project leaders is included in Appendix 1. A variety of special projects were also undertaken during 1989. The following describes these tasks.

(a) Commercial Catch Studies

The 1989 commercial entrapment gear fishery for walleye was monitored by LOFU staff (Project A2) and a report on our findings by Mathers and Bowlby is included in this Annual Report. Annual assessments made with index gillnets in nearshore waters, less than 30 meters, deep was continued in the Kingston basin and in the Central basin (Traverse to Brighton; Project A1). This series provides information on a variety of commercial and sport fish species, and on the fish community in these waters. We plan to expand the series westward to Niagara, and a frame survey will be conducted during the summer of 1990. A report on this 1989 project by Bowlby is included in this Annual Report.

(b) Walleye Stock Assessment

A walleye stock mark-recapture project (Project B1) was conducted during the fall of 1989, and over 16,000 walleye were captured. These data were not used in the population model (report by Mathers and Bowlby in this Annual Report) because we are developing a new technique to determine fish age (Project F5).

Due to reconstruction of the research vessel Namaycush, the usual walleye year-class strength index from the research trawls was not available during 1989. In its place, a preliminary estimate was calculated from the data collected in the outboard trawling project (Project B4). Index gillnets provided data on walleye distributions (Projects A1 and F2). The 1989 creel census in the Bay of Quinte was indexed using data collected during January, February, May and July only (Projects B2 and B3). The report by Mathers and Bowlby (in this document) includes data from the above projects, walleye populations estimates for 1989 and 1990 (based on previous years' data), and an evaluation of several management options.

Angling surveys conducted in the Bay of Quinte during the time period between 1957 and 1980 were entered into electronic data bases (Project H1), and we are preparing to analyse these data in preparation for the upcoming synthesis of walleye fisheries information.

(c) Lake Whitefish Assessment

Assessment work on whitefish is directed at two stocks; Lake Ontario and Bay of Quinte. All mark/recapture work on the Lake Ontario stock was discontinued due to a lack of funds. Whitefish from the Lake Ontario stock are caught in the index nets fished in the Kingston and Central basins (Projects A1 and F1). We suspect that whitefish caught in these projects are a mixture of the two stocks. Further population work awaits the completion of the study to discriminate between bay and lake stocks (Project C2). Whitefish from the Bay of Quinte stock are readily captured during the walleye tagging activity, and continue to be processed as a separate part of that Project (C1).

(d) Lake Trout Assessment

Lake trout assessment continues to be guided by the 'Joint Plan For the Rehabilitation of Lake Trout in Lake Ontario'. An updated version of the plan prepared by OMNR, NYDEC and the USFWS will be released in 1990. These agencies participate in a cooperative yearly index project (E5), collecting data on abundance, survival, and population structure of lake trout and the impact of lamprey on lake trout (Schneider *et al.* this Annual Report). Lamprey attack indices are also collected in Projects D1 and D2.

Lake trout sport harvests are estimated in the western and central basin creel projects (Project E2, Stewart et al. this Annual Report). Mortality due to sport harvest in the Kingston basin was not monitored during 1989. A separate study of spawning adults was conducted by Dr. John Casselman (Project F3).

During April and May of 1989, fry traps were placed at Yorkshire Bar and Stoney Island in attempt to catch lake trout fry emerging from these shoals (Project E6). The work was a cooperative venture involving staff from OMNR, the New York State Dept. of Environmental Conservation (NYDEC) and Cornell University. Fry were captured at Stoney Island as is reported by Schneider et al. elsewhere in this Annual Report.

During 1988, an extensive survey of Yorkshire Shoal, by divers from the Canada Centre for Inland Waters, revealed that suitable substrate for spawning constituted a narrow band approximately three meters wide by two hundred meters in length. During 1989, the fry traps were placed and serviced by divers on the substrate most suitable for spawning. One lake trout fry (190 to 200 days of development) was captured and sent to Cornell University for analysis of its genetic origin.

(e) Assessment of Stocked Salmonids

We have continued to refine our approach to assessment of the salmonid fishery in Lake Ontario. The scope of our program in 1989 increased to include the western and central basin, and a direct survey of charter boat operators and marina based private boat anglers (Project E2). In an attempt to reduce the cost of monitoring we further refined our statistical approach to expansion of effort based on trailer counts (Project E1). Spawning runs of coho and chinook continue to be monitored during the egg taking operation (Projects E3, E4; Plante and Bowlby this Annual Report).

In cooperation with the NYDEC midwater trawling (Project G3), midwater gillnetting and bottom gillnetting (project G2) were all used in attempt to catch salmon. The results of this experiment are described by Schaner in this Annual Report.

(f) Assessment of Smelt and Alewife Abundance

Again this year, the USFWS research vessel KAHO conducted trawling for smelt in the Canadian waters of western Lake Ontario (Project E7). Staff from LOFU assisted in the collections. The results of this survey are reported by Mathers and Stewart in this Annual Report. Exploratory midwater trawling for smelt and alewife were conducted in cooperation with the NYDEC (Project G4) as reported by Schaner in this Annual Report.

(g) Other work involving LOFU staff

Periodically, the results of the studies listed below are published in scientific journals. A list of recent publications is presented in Appendix 2.

From time-to-time, LOFU staff are called upon to serve on committees or conduct work outside our normal programs including: fish stocking, egg collection, and collection of fish for contaminant analysis. A summary of these tasks is presented in Appendix 3.

Staff and Facility Changes

On May 1, 1989, LOFU returned to the Fisheries Station at Glenora from the temporary facilities at Picton Heights. The official opening of the Glenora building was October 3, 1989. The Ontario Ministry of Government Services did a superb job of renovating and updating the Glenora facility. The new facilities at the station are excellent and modern in design and will permit a diversity of research in its laboratories, which have been specially designed to provide healthy and safe working conditions.

D. E. Jeffrey serves as Operations Supervisor; Dr. J. Casselman is the Senior Scientist; Tom Stewart assumed the position of the Supervisor of the Assessment Unit, September 25, 1989, after the retirement of William Dentry. Jim Bowlby was appointed to the staff Biologist position at Richmond Hill. Dawn Walsh was appointed the position of Senior Technician at Glenora. The technical operations were reorganized to three division: (1) Marine and Fishing Services - Senior Technician Chuck Wood, (2) Base Operations - Senior Technician Wayne Miller, and (3) Field Operations - Senior Technician Dawn Walsh. A list of staff employed at LOFU appears in Appendix 4.

The LOFU office, which coordinates much of the work in the western end of Lake Ontario, has been relocated from Richmond Hill to 820 Yonge Street South, RR#2 Aurora, Ontario, L4G 3G8.

Vessel Reconstruction

Since November 1988, the research vessels Namaycush and Steelcraft have been at Harry Gamble Shipyards in Port Dover, Ontario for major rebuilding. The vessels will return to Glenora in the spring of 1990 fully equipped for trawling and gillnetting. The Namaycush was lengthened to 50', a new hydraulic system, wheelhouse and shelter deck, diesel generator, and a new 200 hp marine diesel engine were installed. The Steelcraft had a new wheelhouse and shelter deck, a hydraulic systems, and a diesel generator installed.

Commercial Landings in Napanee District

During the 1989 calendar year, the commercial fishermen reported harvesting a total of 1,199,041 pounds (round weight) of fish with a landed value of $983,305 as shown below.

Species	1989 Landings lb	Price per lb	1989 Landed Value
Bullheads	282,558	0.40	$113,023
Carp	123,892	0.27	33,451
Catfish	22,948	0.27	6,196
Crappies	16,663	1.58	26,327
Eels	230,932	1.29	297,902
Drum	8,513	0.21	1,788
Lake Herring	3,329	0.58	1,931
Lake Whitefish	125,374	1.25	156,717
Rock Bass	22,423	0.35	7,848
Sunfish	64,903	0.46	29,855
Suckers	25,478	0.19	4,840
White Bass	4,049	0.74	2,996
White Perch	41,577	0.40	16,631
Yellow Perch	215,342	1.25	269,178
Dogfish	6,612	0.23	1,521
Walleye	16,266	1.19	19,357
Ling	4	0.25	1
Total	1,210,863		$989,563

Lake Ontario Fisheries Management Plan

On July 3, 1986 a three-man planning subcommittee was created by the Lake Ontario Management Committee to develop a Lake Ontario Fisheries Management Plan. It was decided that the Lake Ontario Plan would be consistent with the provincial planning guidelines for District Fisheries Management Plans (DFMP) and would progress in concert with the plans of the five districts bordering Lake Ontario. For most districts bordering the lake, audio visual presentations, fact sheets and questionnaires relating to Lake Ontario were presented at two rounds of public consultation meetings. The Lake Ontario Plan is currently on hold pending district completion and approval of their final DFMP's. The extension of commercial fisheries modernization initiatives in eastern Lake Ontario has also caused planning delays. A draft Lake Ontario plan is anticipated by mid-1990.

Acknowledgments

Thanks to Linda Balsillie, Carol Ward, Linda Blake, Herta Jorens (Central Region Office), and Gail Coville (Brockville District Office) for copy editing and the production of this manuscript.

APPENDIX 1. Programs conducted by the Lake Ontario Fisheries Unit between April 1, 1989 and April 1, 1990.

A. Commercial Fish Assessment Program

Project A1 Index gillnetting
Project leader: Jim Bowlby

Project A2 Walleye commercial trapnet fishery monitoring
Project leader: Jim Bowlby

B. Walleye Stock Assessment Program.

Project B1 Fall mark-recapture project
Project leader: Alastair Mathers

Project B2 Bay of Quinte summer creel census
Project leader: Jim Bowlby

Project B3 Bay of Quinte winter creel census
Project leader: Alastair Mathers

Project B4 YOY Outboard trawling
Project leader: James Bowlby

C. Lake Whitefish Stock Assessment Program

Project C1 Fall tagging in the Bay of Quinte
Project leader: James Bowlby

Project C2 Stock Identification Study
Project leader: Dr. John Casselman

D. Lamprey Monitoring Program

Project D1 Coho and chinook Spawning Runs
Project leader: Tom Stewart

Project D2 Research index netting
Project leader: Dr. John Casselman

E. Salmonid Assessment Program.

Project E1 Western Lake Ontario trailer count modelling
Project leader: Tom Stewart/Brian Malone

Project E2 Lake Ontario salmonid harvest assessment
Project leader: Tom Stewart

Project E3 Coho spawning run monitoring
Project leader: Tom Stewart/Jim Bowlby

Project E4 Chinook spawning run monitoring
Project leader: Tom Stewart/Jim Bowlby

Project E5	A cooperative (DEC/OMNR/FWS) index gillnet fishery for adult lake trout
Project leader:	William Dentry/Ted Schaner
Project E6	Lake trout fry traps
Project leader:	William Dentry/Ted Schaner
Project E7	Smelt trawling (DEC/OMNR/FWS)
Project leader:	Tom Stewart /Alastair Mathers

F. Research Program

Project F1	Fish Community Dynamics - Outlet Basin
Project leader:	Dr. John Casselman
Project F2	Fish Community Studies - Bay of Quinte
Project leader:	Dr. Don Hurley
Project F3	Lake Trout Rehabilitation Studies
Project leader:	Dr. Don Hurley/Dr. John Casselman
Project F4	Sampling Variability Studies
Project leader:	Dr. John Casselman
Project F5	Digitized age interpretation from fish scales
Project leader:	Dr. John Casselman

G. Community Oriented Lake Assessment (COLA) Program

Project G1	Vessel reconstruction
Project G2	Exploratory bottom and midwater gillnet sets
Project G3	Exploratory salmonid midwater trawling
Project G4	Exploratory smelt and alewife midwater trawling
Project leader:	Ted Schaner (G1-G4)

H. Special Projects:

Project H1	Bay of Quinte historical creel survey analysis
Project leader:	Alastair Mathers
Project H2	Bay of Quinte Remedial Action Plan
Project leader:	Dr. Don Hurley

APPENDIX 2. Research papers published by LOFU staff during 1989.

BOWLBY, J.N., A. MATHERS, D.A. HURLEY, and T.H. ECKERT. 1990. The resurgence of walleye in Lake Ontario. Walleye Rehabilitation Workshop. Special Publication of Great Lakes Fishery Commission. in press.

APPENDIX 3. Other work involving LOFU staff.

Description	Person
1. Secondment as Acting District Biologist at Napanee District Office	A. Mathers
2. GLFC Walleye Rehabilitation Workshop C. Lewis and P. Colby, cochairpersons	J. Bowlby A. Mathers D. Hurley
3. COLA Steering Committee cochairman	Wm. Dentry
4. COLA Technical Committee, chairman	T. Schaner
5. Lake Ontario Stocking Committee (chairman, S. Kerr)	Wm. Dentry T. Stewart
6. Lake Trout Synthesis working group (developing sampling methodology)	T. Schaner
7. Lake Trout Synthesis working group (population dynmaics subgroup)	T. Stewart

8. Atlantic Salmon Steering Committee (chairman R. Desjardin)	T. Stewart
9. Lake Synopsis Review Committee	T. Stewart J. Bowlby
10. Re-write of the lake trout rehabilitation plan	Wm. Dentry T. Schaner
11. Walleye egg collection for White Lake Fish Culture Station	D. Dewey S.Lawrence
12. Fish collections for contaminant analysis	Operations Staff

APPENDIX 4. LOFU Staff in 1989.

Staff at LOFU:

Dave Jeffrey, Operations Supervisor

Dr. John Casselman, Sr. Scientist
Dr. Don Hurley, Scientist

W. Jack Christie, Great Lakes Research Coordinator
Dr. Peter Sly, Visiting Scientist (Rawson Academy)
Cheryl Lewis, Warmwater Fisheries Specialist

William Dentry/Tom Stewart, FAU Supervisor
Ted Schaner, FAU Biologist
Alastair Mathers, FAU Biologist
Jim Bowlby, FAU Biologist

John Kinney, Administrative Clerk
Carol Ward, Receptionist and Secretary
Linda Balsillie, Secretarial Support
Linda Blake, Secretarial Support

Ken Scott, Computer Systems and Database Manager
Kelly Garbutt, Data Entry
Jeff Church, Age Determination Technician

Chuck Wood, Senior Technician
Wayne Miller, Senior Technician
Dawn Walsh, Senior Technician
Dale Dewey, Technician
Steve Lawrence, Technician
Joe Dibbits, Technician
Tim Shannon, Technician
Steve Welham, Technician
Jim Boraski, Technician
Terry Cronin, Technician
Randy Gurnsey, Technician
Grant Robinson, Technician
Chris Grooms, Technician
Peter Klaassen, Boat Captain

LOFU Staff at Richmond Hill

Tom Stewart/Jim Bowlby, FAU Biologist
Paul Savoie, Fisheries Management Planning
Brian Malone, Biologist
Celine Plante, Biologist

Walleye Populations In Eastern Lake Ontario And The Bay Of Quinte, 1989

Alastair Mathers and James Bowlby

Ontario Ministry of Natural Resources
Lake Ontario Fisheries Unit
R.R. #4, Picton, Ontario. K0K 2T0

Lake Ontario Fisheries Unit, 1989 Annual Report, LOA 90.1 (Chapter 2)

The "fishable" walleye population (aged 2 yr and older) in eastern Lake Ontario was estimated at 733,582 in the spring of 1989. The 1989 year-class is of relatively good size. The walleye population size appears to have stabilized. The ice fishing effort is continuing to grow steadily and the harvest of walleye was much larger than 1988. The open water angling effort was similar to 1988. The walleye harvest during the open water season was larger than during 1988, primarily due to the strong 1986 and 1985 year-classes. The commercial fishery was allotted a quota for walleye harvest for the first time since 1983. Commercial harvest was restricted to fish caught in entrapment gear outside the Bay of Quinte (Quota Zones 1, 2.1, and 2.2). Slot limit regulations restricted the commercial harvest of walleye to 18" to 24" total length. Simulations of the effect of varying angler bag limit, minimum size limit for angling, commercial quota size, and commercial slot limit size were conducted using the walleye model.

Recommendations

1. Continue the mark-recapture program in 1990 to allow further calibration of the walleye model.
2. To improve our ability to predict future walleye populations we should continue to assess the stock-recruitment relationship and also try to quantify natural mortality.
3. Complete aging of 1989 walleye and incorporate the subsequent population analysis in the walleye model.
4. Consider the potential impact of zebra mussels on the walleye population and investigate methods of reducing the impact.

Introduction

This report is the annual update of the status of walleye (*Stizostedion vitreum*) in the Canadian part of eastern Lake Ontario and the Bay of Quinte (Fig. 1). It includes results of the 1989 surveys of the Bay of Quinte ice fishery and open water fishery, and a summary of the 1989 commercial trapnet fishery for walleye. The walleye mark-recapture project was continued in 1989, however, the analysis was not complete at the time of publication because we are developing a new technique for determining the age of fish. The ages referred to in this report rely on age and growth analysis from previous years. The walleye model (Bowlby and Mathers 1989) was used to predict the 1990 fisheries. The model was also used to predict the effect of several potential management strategies including: changes to the angler bag limit, a minimum size limit for angling, increasing the commercial walleye quota and, increasing the slot limit on the commercial walleye fishery.

Between the early 1900s and the 1960s walleye were an important component of the commercial fishery in Eastern Lake Ontario (Baldwin et al. 1979). The Bay of Quinte stock declined during the 1960s (Hurley and Christie 1977), but rebounded after 1977 (Hurley 1986). The decline was concurrent with an increase in the white perch (*Morone americana*), and excessive eutrophication, but was not believed to be the result of overexploitation (Hurley and Christie 1977). After improvements in domestic sewage treatment and after a winterkill of alewife a strong year-class of walleye was produced in 1977. A much stronger year-class was produced in 1978 after a large winterkill of white perch (Hurley 1986). White perch, alewife and eutrophication can all be hypothesized as agents responsible for the 1960s decline and subsequent resurgence of walleye in the Bay of Quinte but no single factor has been identified (Bowlby et al. 1989).

Angling surveys have been conducted on the Bay of Quinte since 1957 (Christie 1958) and all of these studies have shown that by far the most abundant fish species in the anglers' harvest is the walleye. Recently, the Bay of Quinte walleye angling fishery has consisted of an ice fishery during January and February and an open water fishery from May to freeze-up (usually late December). During 1989 the fishing season closed on February 29 and re-opened on May 6. There was a four fish daily bag limit with no restrictions on the size of fish harvested. Also anglers are restricted to one fishing line during the open water fishery and two lines during the ice fishery.

During 1989 commercial fishermen were allotted a 30,000 lb. quota for walleye. This followed a complete ban on the commercial harvest of walleye in Lake Ontario from 1984 to 1988. During 1989 fish were harvested in entrapment gear by commercial fishermen in quota zones 1, 2.1 and 2.2 of Lake Ontario (Fig. 1). A "slot size" restricted harvest to walleye between 18 and 24 inches total length, and the open season ran from May 15 to June 23, 1989.

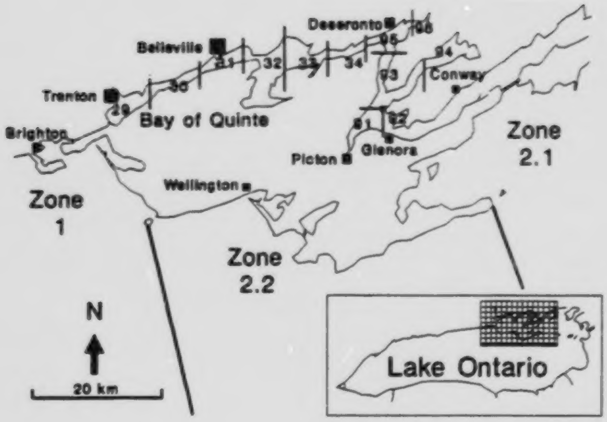

FIG. 1 The Bay of Quinte and Eastern Lake Ontario showing the twelve areas used in the 1989 angling fishery surveys. The following names are used in reference to these areas: 29-Trenton, 30-Maketewis Island, 31-Belleville, 32-Point Anne, 33-Trident Pt., 34-Telegraph Narrows, 95-Deseronto, 96-Napanee River, 93-Long Reach, 94-Hay Bay, 92-Baggot's Bay, 91-Picton Bay. Also shown are commercial fishing zones 1, 2.1 and 2.2.

Methods For Commercial Catch Sampling

Lake Ontario Fisheries Unit staff sampled the harvested and released walleye with good cooperation from the commercial fishermen. LOFU staff observed 37.3% of the total walleye harvest during 19 dockside and 35 onboard samples. Some fishermen could not be readily sampled onboard because of insufficient space for LOFU staff. For these fishermen we used dockside samples of harvested walleye and the fishermen's estimate of the weight of discarded walleye. A complete description of the sampling methods and a summary of the data can be found in Bowlby (1989).

Methods For Angling Surveys

The basic design of these surveys and subsequent data analysis were carried out using CREESYS (Lester and Trippel 1985). The angling surveys were stratified by space, day-type (weekends and weekdays), and season to reduce the variance of the angling effort and harvest estimates. These angling surveys covered the Bay of Quinte from Trenton to Glenora and included 12 geographic strata (Fig. 1).

The surveys combined angling activity counts with interviews conducted with anglers on the water (or ice). During the open water fishery aerial boat counts were conducted during May when angling pressure was expected to be high enough to make counting on the water inefficient. During other times boat counts were conducted on the water. In the winter aerial counts were adopted because poor weather and ice conditions often made it difficult to collect activity count data.

The ice fishing survey was conducted from January 4 to February 29, 1989. This whole time period was considered to be one season. Day-types were stratified into weekend days and week days. All angling was assumed to be conducted between 0700 and 1700 hours. A more detailed summary of the methods used in the ice fishing survey can be found in Mathers (1989).

The open water angling survey was conducted from May 6 (the opening day of the walleye season) until June 4 and also from June 26 until July 23. These time periods represent three of the six open water fishing seasons (Table 1). Day-types were stratified into workdays and non-workdays.

The estimate of the walleye catch, harvest, and angling effort for the open water season (May 6 to December 15) was expanded from survey estimates for the months of May, and July using the seasonal patterns for the 1988 season as the expansion factors (Table 1). A more detailed summary of the methods used in the open water fishing survey can be found in Bowlby (1989).

Table 1. Description of the seasons used in the 1989 angling survey. Only the Opening Weekend, May and July seasons were sampled. The other seasons were extrapolated from the total of May and July and the seasonal pattern of walleye catch, walleye harvest, and angler effort (rod hours) observed in 1988. The expansion factors derived from the 1988 data are shown.

Season	Catch	Harvest	Effort
Opening Weekend - May 6 to 7	0.102	0.148	0.368
May - May 8 to June 4 - next four weeks	0.633	0.609	0.688
June - June 5 to June 25 - remainder of June	0.066	0.061	0.153
July - June 26 to July 23 - week including July 1 + next 3 weeks	0.367	0.391	0.312
Aug. - July 24 to Sept. 4 - remainder of July to Labour Day	0.180	0.232	0.408
Fall - Sept. 5 to Nov. 31 - remainder of Sept. to end of Nov.	0.053	0.046	0.158

Estimates Of Walleye Population Size

The population estimate of "fishable" walleye (aged 2 yr and older) in eastern Lake Ontario is 733,582 for the spring of 1989 (Fig. 2). Generally, the population has varied between 0.7 and 4 million fish during 1979 to 1989. For the ten years prior to 1979 the fishable population was probably less than 200,000 fish. The large population in the early 1980s was due to the unusually strong 1978 and 1977 year-classes. These two strong year-classes have been reduced in numbers in recent years because of natural mortality and fishing harvests. These year-classes were produced in unusual conditions (low competition and predation) and should not be expected to re-occur in the near future (Bowlby et al. 1990). The population appears to have reached a state of some stability in the current harvest and environmental conditions.

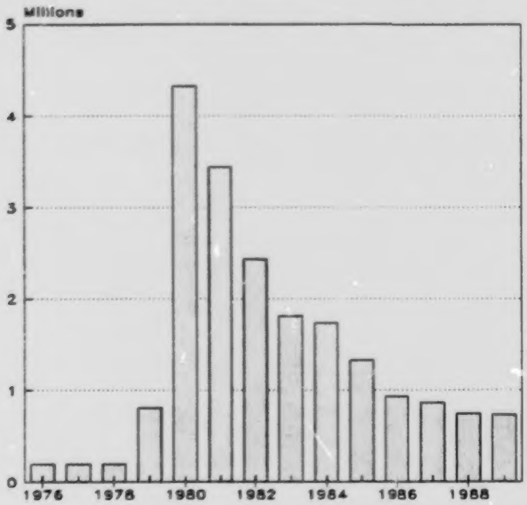

FIG. 2. Population estimates of 2 yr and older Bay of Quinte walleye during fall from 1976 to 1989.

The recent population estimates do not differ greatly from the estimate of 1,000,000 walleye (older than 2 yr) in 1958 (Hurley and Christie 1977). The catch in the Hay Bay index gillnets also seems to indicate that the current population is similar to those observed in the late 1950s and early 1960s (Fig. 3). Gillnet catches in Lake Ontario suggest that the walleye population in some areas is at a similar density to that of the Bay of Quinte (Fig. 4).

Age Structure And Year-Class Strength

The research trawling program was cancelled during 1989; therefore, the usual index of walleye year-class strength was not available. The outboard trawl program was started in 1988 and continued in 1989. The ratio of YOY walleye catch in outboard trawls in 1989 relative to 1988 was used to estimate the what the catch in the research trawl program would have been for 1989. This preliminary estimate suggests that the 1989 year- class of walleye is relatively strong and is similar in size to that observed in 1985 (Fig. 5). During 1989, YOY walleye catches in the outboard trawls increased 40%, relative to 1988, but the increase was not statistically significant (paired t-test, $t=0.92$, $p=0.39$). The largest catches of YOY walleye in 1989 were observed at the sites in the Bay of Quinte near Trenton, Belleville, and Big Bay (Bowlby 1989).

The age structure of the walleye population during 1988, 1989, and 1990 shows the strength of the 1987, 1982, and 1978 year-classes (Fig. 6). The 1985 to 1989 year-classes are all relatively large and should provide for stable fishing harvest levels in the near future.

1989 Walleye Harvest By The Commercial Fishery

Commercial fishermen reported a walleye harvest of 16,326 lb (7,421 kg) which we estimated to be 3,908 walleye. The harvest was 54% of the quota of 30,000 lb set for the commercial fishery. We estimated the released walleye to be 33,059 lb (15,027 kg) and 5,642 in number. Of the fish we observed released, only 0.3% were dead.

The fork length distribution of the commercial fishermen's catch of walleye (Fig. 7) suggests that the catch was dominated by fish older than 4 yr. This was expected because most of the catch occurred in Quota Zone 2.2 (Fig. 1). Most walleye caught in this area are believed to have recently migrated from the Bay of Quinte, and this migration is comprised predominantly of older fish. Younger walleye tend to stay in the Bay. However, in Quota Zone 2.1 significant numbers of 2- and 3-yr old fish were caught. Many of these fish probably originated from East Lake and West Lake rather than the Bay of Quinte. Few fish were caught in Quota Zone 1.

The fork length distribution suggests the harvest was dominated by ages 5, 6, and 7 (Fig. 7). The 1982 year-class (age 7) was strong and accounted for much of the harvest. The 1977 and 1978 year-classes were quite vulnerable to the commercial trapnets but were protected from harvest by the slot limit. We observed a very limited harvest of fish outside the slot limit.

1989 Angling Harvest Of Walleye During The Ice Fishing Season

The angling effort during the 1989 ice fishery (January 2 - February 28) was estimated at 207,691 rod hours (165,913 angler hours, Table 2). The angling effort during the ice fishing season appears to be growing steadily (Fig. 8). During 1989, as in the past, the angling effort attributed to "on-ice anglers" (110,870 rod hours) was very similar to that for "hut anglers" (96,822 rod hours).

Table 2. The estimated angling effort (rod hours), walleye catch and walleye harvest for the 1989 angling fisheries on the Bay of Quinte.

Season[1]	Walleye Catch	Walleye Harvest	Angling Effort
Jan. Feb.	25,458	19,147	207,691
Opening Weekend	18,355	12,774	61,553
May	125,102	66,304	170,231
June[2]	11,129	5,554	37,590
July	43,553	24,398	74,885
August[2]	30,424	21,042	100,046
Fall[2]	8,878	4,144	38,642
Open Water Total	237,44	134,216	482,947
Annual Total	262,899	153,363	690,638

[1] See Methods for definition of seasons.
[2] Estimated based on current years' May and July total and the trend through the season from 1988.

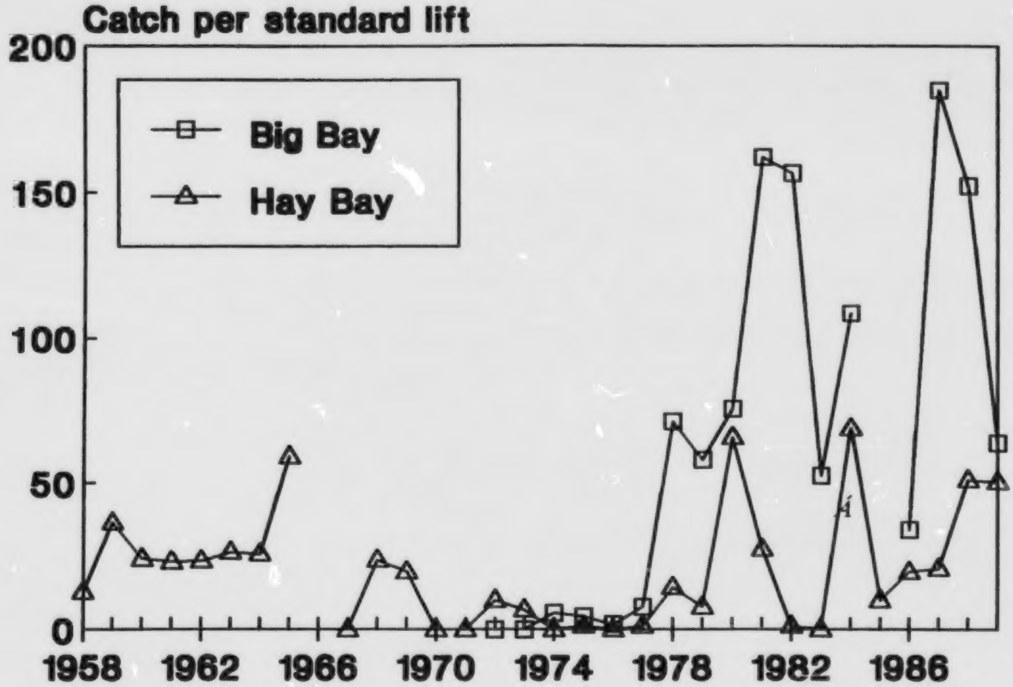

FIG. 3. Trends in walleye catch in index gillnets in the Bay of Quinte for June and August combined, 1958 - 1989.

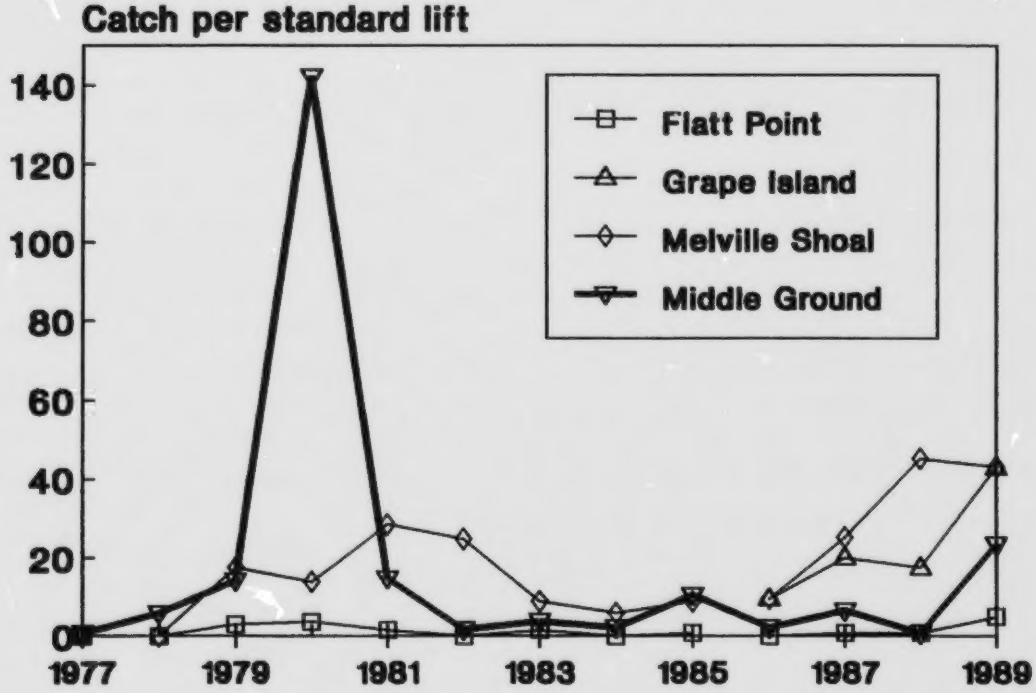

FIG. 4. Trends in walleye catch in index gillnets in Lake Ontario for late July and August, 1977 - 1989. Data for 1986 to 1989 (except Middle Ground) are for the combined depths of 7.5 m and 12.5 m.

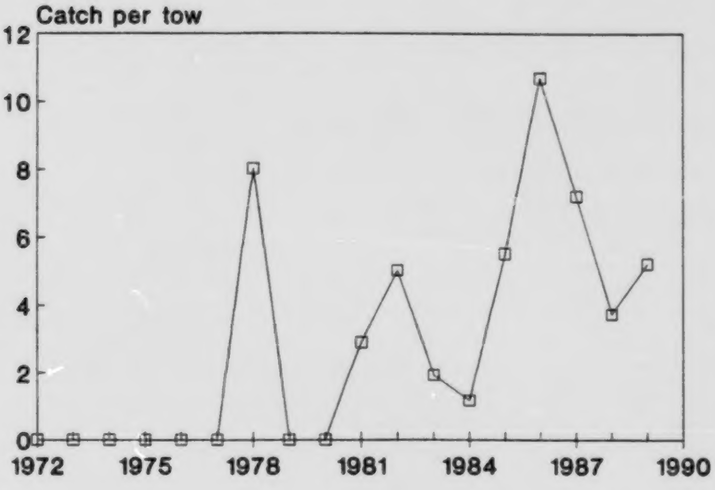

FIG. 5. Mean catch of YOY walleye in trawls in the Bay of Quinte during August and September, 1972 - 1989. Note that the 1989 estimates was derived from the outboard trawl program (see text).

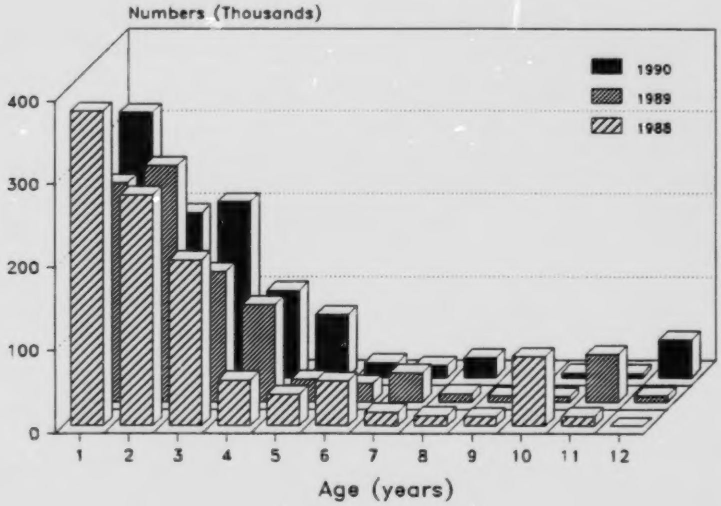

FIG. 6. Eastern Lake Ontario walleye population structure for spring of 1988 to 1990.

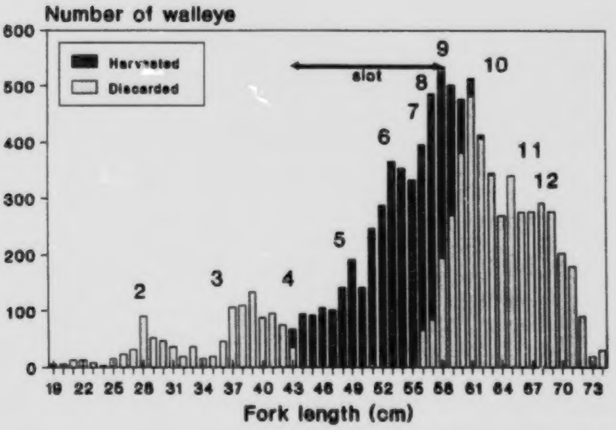

FIG. 7. Fork length distribution of walleye observed during the 1989 commercial fishery. The slot limit for harvest was 43 to 58 cm fork length (18" to 24" total length). The mean fork length at age (Bowlby et al. 1989) is shown to give approximate age of catch and harvest.

Geographic differences in angling activity were evident. The highest angling effort was observed near Trident Point (area 33) and Point Anne (area 32) (Fig. 1). Angling effort in the Deseronto (area 95) area was much lower than in the past, while the Long Reach area (area 93) had much greater angling effort than in the past. It seems likely that the poor ice conditions at Deseronto caused a shift in the angling effort to Long Reach.

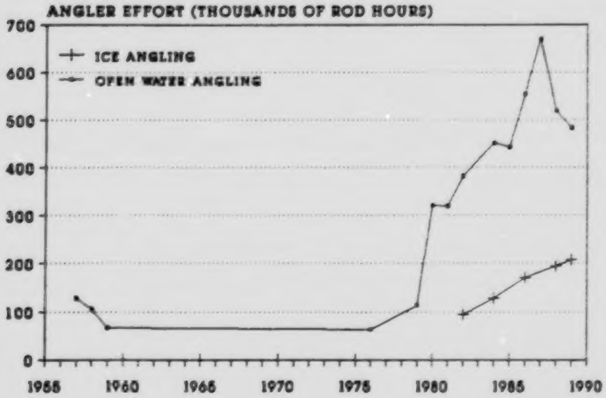

FIG. 8. Angling effort during open water and ice fisheries in the Bay of Quinte from 1957 - 1988.

Lake trout, lake herring, lake whitefish, northern pike, carp, channel catfish, yellow perch and walleye were all observed in the harvest (Table 3). The harvest of walleye during the 1989 ice fishery (19,147 fish, 33,278 kg) was much larger than that observed in 1988 (7,416 fish, Fig. 9). It is possible that 1988 ice fishing harvest was low because the walleye had a decreased vulnerability to angling caused by high numbers of prey species, especially YOY gizzard shad, present in the Bay during the winter of 1988 (pers. comm.) with D. Dewey, Lake Ontario Fisheries Unit, 1990).

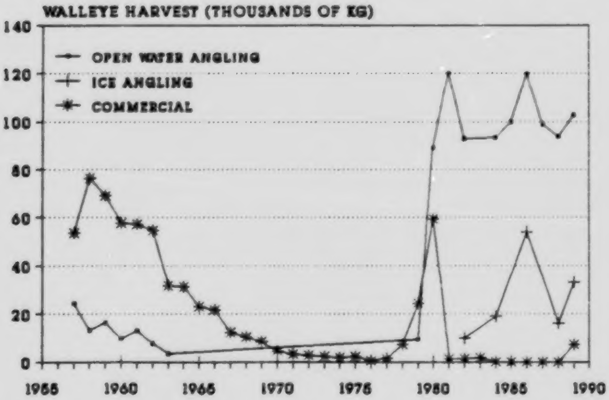

FIG. 9. Walleye harvest (by weight) during commercial fishery, open water angling and ice angling fisheries in the Bay of Quinte from 1957 - 1988.

The harvest of walleye was largest in the Trident Point, Hay Bay, Point Anne, and Maketewis Is. areas. The rates of harvest were best at Hay Bay, Maketewis Is. and Deseronto.

The 1989 harvest of yellow perch (36,948 fish) was similar to the estimate for 1988 (39,914 fish) but much higher than the harvest in 1986 (1,218 fish). The numbers of all other species of fish harvested was very low (Table 3).

Table 3. Estimated catch and harvest of fish during the 1989 ice angling survey on the Bay of Quinte. Standard error of the estimate is shown in brackets.

Species	Catch	Harvest
Lake Trout	78 (72)	78 (72)
Lake Whitefish	13 (12)	13 (12)
Lake Herring	14 (13)	14 (13)
Northern Pike	996 (391)	518 (139)
Common Carp)	49 (45)	49 (45)
Channel Catfish	37 (34)	37 (34)
Yellow Perch	66212 (7896)	36948 (5560)
Walleye	25458 (4743)	19147 (3324)

The average size of walleye harvested during the ice fishery was 1.738 kg. The 1986 and 1985 year-classes were the most abundant in the harvest, however most year-classes were well represented (Fig. 11).

1989 Angling Harvest Of Walleye During The Open Water Season

The angling effort was estimated at 482,947 rod hours for the 1989 open water fishing season (May 6 to December 31). This is similar to 1988 but somewhat lower than 1987 (Fig. 8). The decline in angling effort since 1987 coincides with the growth of the salmonid angling fishery near Wellington and Brighton (Stewart et al. 1990), and we speculate that these events may be related.

The estimates of angling effort during May and July were very similar to those observed in 1988. However, the estimate for the opening weekend (61,553 rod hours) was lower than observed in 1988 (91,323 rod hours), possibly due to the poor weather conditions.

The harvest of walleye during the 1989 open water season is estimated at 134,217 fish (104,958 kg) an increase over the harvest observed in 1988 (119,125 walleye) (Fig. 9). The walleye harvest rate (0.278 fish/rod hr.) and catch rate (0.492) for 1989 were also higher than those observed during 1988 (0.230 and 0.411 respectively) (Fig. 10). These harvest rates are indicative of a very good walleye angling fishery (Colby et al. 1979). The good angling harvest rates are primarily due to the presence of the strong 1985 and 1986 year-classes.

The harvest rate during the opening weekend (0.208) and during May (0.382) were higher than the rates observed during 1988 (0.130 and 0.285 respectively).

The average size of walleye harvested during the open water fishery was 0.782 kg. Fish from the 1986 year-class (3 yr old) were the most abundant in the harvest (Fig. 11). The 1987 and 1985 year-classes (2- and 4-yr old) were also well represented in the harvest. The older fish were harvested in relatively small numbers.

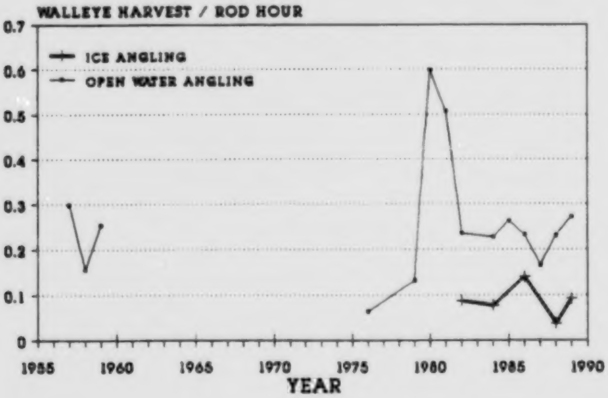

FIG. 10. Angling harvest rates during open water and ice fisheries in the Bay of Quinte from 1957 - 1988.

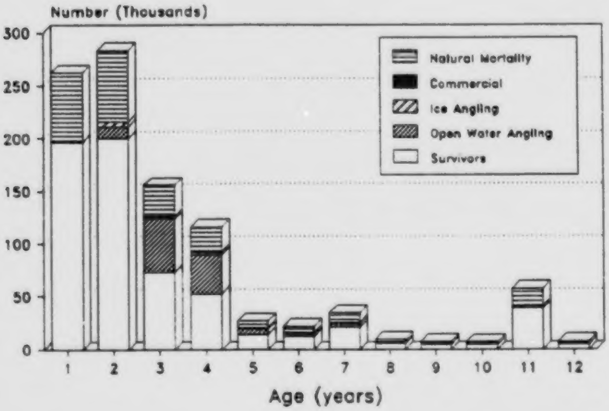

FIG. 11. Estimated age structure of the Eastern Lake Ontario walleye population during 1989.

Predictions Of The Walleye Harvest For 1990 And Beyond

The walleye model suggests that during 1990 the angling fishery will continue to show good results. The 3- and 5-yr old fish will be more abundant in 1990 than during 1989 (Fig. 6 and Fig. 12). This should lead to good harvests of walleye particularly during the open water fishery. Lower numbers of 2 yr old fish will be present during 1990 which will not strongly effect the harvest but may lead to slightly lower catch rates overall.

During 1989, the commercial fishery harvested primarily 5-, 6-, and 7-yr old fish. The 1984, and 1983 year- classes (during 1989, 5- and 6-yr old respectively) were relatively weak (Fig. 5). During 1990, the strong 1985 year-class will be more vulnerable to the commercial fishery. This should allow the commercial fishery a more successful harvest.

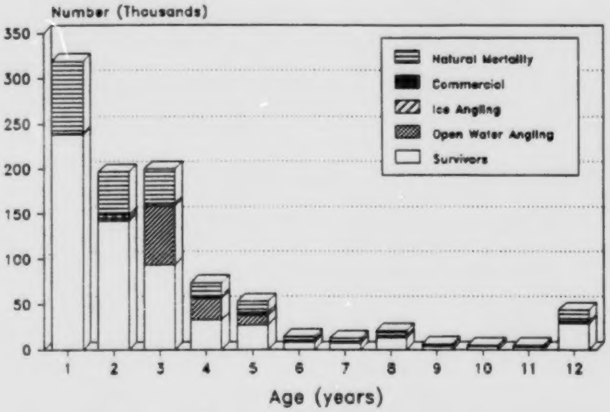

FIG. 12. Predicted age structure of the Eastern Lake Ontario walleye population during 1990.

The 1989 year-class appears to provide promise of good fishing in the future. The year-classes produced since 1985 have been relatively consistent suggesting that the population has stabilized (Fig. 5). The factors which control year-class strength are not completely understood (Bowlby et al. 1989) and deserve more study.

A large population of the zebra mussel (*Dreissena polymorpha*) is expected to develop in the near future in the Bay of Quinte. If the mussel population expands to the extent it has in Lake Erie there is a strong potential for an effect on the walleye population as well as other fish species.

One potential effect is degradation of walleye spawning shoals. The Bay of Quinte walleye population spawns on rocky shoals found both in rivers and along lake shorelines. It is not clear what the relative importance of the river and lake shoreline spawning shoals are to the Bay of Quinte population. Zebra mussels have been found to degrade lake shoreline spawning shoals in western Lake Erie. Densities as high as 30,000 mussels m^2 were recorded in 1989 (pers. comm. with S. Nepsey, Lake Erie Fisheries Research, 1989). The mussels are not thought to degrade river spawning shoals since they do not generally inhabit flowing water.

Another potential effect of the zebra mussel is a shift in the aquatic food chain in the Bay of Quinte (pers. comm. with D. Hurley, Lake Ontario Fisheries Unit, 1989). The food chain in the Bay of Quinte will exhibit an increase in benthic production with an increase in the zebra mussel population. This may cause a reduction in planktonic production. Shifts in the food chain would affect the ability of walleye to compete for food and hence affect their survival. However, it is not possible at this time to foresee the overall effect of zebra mussels on the walleye population.

The experience with zebra mussels in Lake Erie suggest that we should be concerned about the implications to the Bay of Quinte walleye population. We recommend that further documentation of the zebra mussel population in the Bay of Quinte and a plan to try to minimize the effect of the zebra mussels be considered.

Management Options To Effect Walleye Harest Levels

Several options to change the walleye harvest are available to the managers of this fishery such as: change the commercial slot limit, change the commercial quota, change the angling bag limit for walleye, implement a minimum size of walleye that anglers are allowed to harvest. We evaluated the influence of these options on the walleye population using the walleye model (Bowlby and Mathers 1989). It should be remembered that the current model is not capable of long term predictions; however, it is a useful tool to predict the relative influence of management options up to 2 years into the future.

Changes to the angling fishery bag limit have a strong potential to effect walleye harvest (Fig. 13). The current bag limit is set at 4 walleye per day. If the bag limit was reduced to 3 fish per day the walleye harvest would be reduced by 14,047 fish (9% of angling harvest). If the bag limit was increased to 6 fish per day, the walleye harvest would be increased by 14,886 fish (10% of the angling harvest).

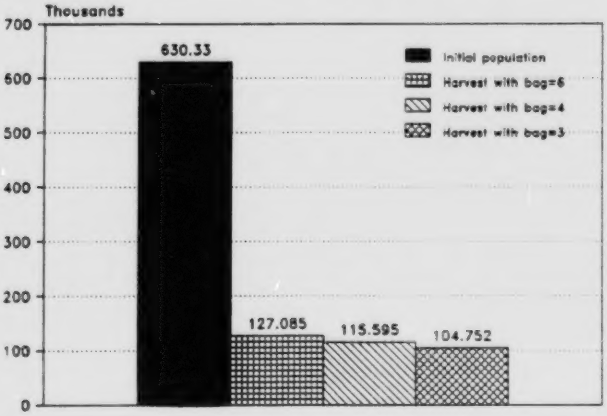

FIG. 13. Simulated effect of varying the walleye bag limit on the number of walleye harvested by anglers during 1990. The spring 1990 population size is shown for reference.

During the 1989 open water fishery, we estimate that over 100,000 walleye were caught and subsequently released by anglers. Currently the majority of released fish are -1 and 2-yr old. In the early 1980s, the angling fishery harvested large numbers of small fish. The recent increase in the release rate of small walleye could be due to the increased popularity of catch and release fishing and/or the absence of larger fish available for the angler to harvest during the early 1980's.

If a 30 cm minimum size limit were put into effect it would avoid the potential for harvest of 1- and 2-yr old walleye. This would not reduce the current harvest levels since the majority of the fish less than 3 yr old are being released. However, if future production of walleye in the Bay declines in the absence of a minimum size limit then anglers may harvest smaller fish which they previously would have released. A minimum size limit would help reduce harvest and compensate for the decline in walleye production.

The quota currently allowed the commercial fishery (30,000 lb.) is small relative to the population size and the other sources of mortality (Fig. 14). We estimate for 1990, that if the 30,000 lb. quota was completely harvested it would represent only 1% of the total population by number and 2% of the population by weight. The portion of the population which would feel the greatest effect of the 1990 commercial fishery are the 1986, 1985, 1984, and 1983 year-classes. The largest mortality, which can be attributed to the commercial fishery, in any one year-class is 5%. Increasing the commercial quota to 50,000 lb. would not have any short term effects on the walleye angling fishery. Our uncertainty about the stock-recruitment relationship does not allow us to predict the long term effect of any changes with certainty.

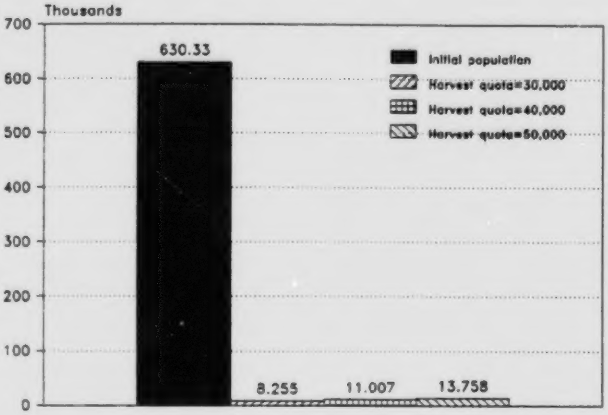

FIG. 14. Simulated effect of varying the commercial fishing quota size on the number of walleye harvested by the commercial fishery during 1990. The spring 1990 population size is shown for reference

The walleye model suggests that changing the lower slot limit would have an influence on the age of the walleye harvested in the commercial fishery. However, with a 30,000 lb. quota, these changes are very small with respect to the population (Fig. 15). Changing the slot limit to 16" to 24" could increase the numbers of 4 yr old walleye in the harvest by 1,720 fish. A corresponding decrease in the harvest of older fish is also predicted. This increase represents a 70% increase in the harvest of 4 yr old fish (relative to a 18" to 24" slot) but only 2% of the 4 yr old population.

Another factor may also increase the harvest of smaller fish by the commercial fishery. Fish processors currently pay a higher price per pound for fish at the lower end of the current slot limit. Therefore, we anticipate that in the coming years commercial fishermen will select for smaller fish. This change in the selectivity of the commercial fishery will have an effect similar to lowering the slot limit.

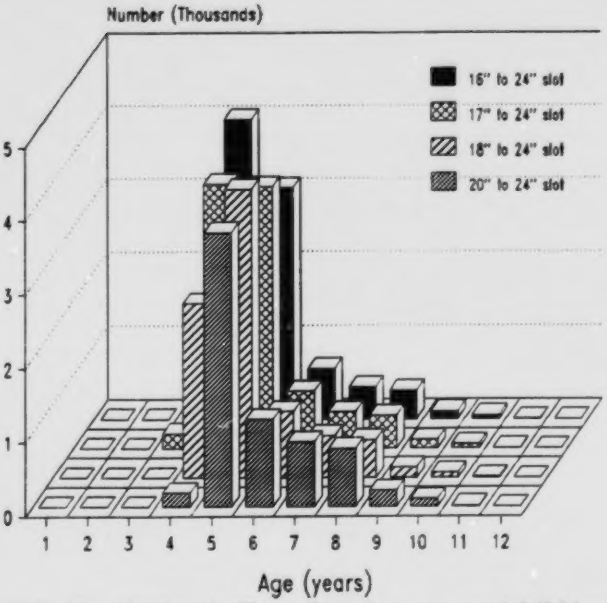

FIG. 15. Simulated effect of varying commercial fishing slot limit size on the age structure of the commercial fishing harvest of walleye during 1990.

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The Relationship Between Walleye Populations and Index Gill Net Catches in the Bay of Quinte.

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Bay of Quinte index gill net data from 1958 to 1988 and walleye mark-recapture data were examined to evaluate walleye catches in summer months to determine the optimum period for index gill net sampling of walleye in the Bay of Quinte, and to test the relationship between walleye index gill net catches and walleye population estimates in the Bay of Quinte. Two indices of walleye year-class strength were developed from the index gill net catches for comparison with population data using ages 2 to 5 inclusive. The 2 yr old walleye population in the Bay of Quinte can be predicted from index gill net catches of the same year-class for ages 2 to 5. The Hay Bay site (BQ05) is a poor index of walleye populations.

Recommendations

1. July appears to be the best summer month to sample the Bay of Quinte with gill nets if the sampling program is confined to a single month.
2. The Hay Bay site (BQ05) should be transformed into a depth stratified site like those in the Nearshore Index Gill Netting Program.
3. Some of the sites that were dropped in 1981 should be picked up again for a more complete survey. Further analysis of the data from these sites is required to determine which sites should be picked.

Introduction

Index fishing is assumed to provide a relative index of abundance of fish species. Index gill net fishing has been ongoing in the Bay of Quinte at a site in Hay Bay since 1958 (Hurley 1987). Nine additional sites were added throughout the Bay of Quinte between 1972 and 1978. Of these 10 sites (Fig. 1) only three were sampled since 1981. This index program has been the responsibility of the Research Unit at Lake Ontario Fisheries Unit, but in the near future this responsibility will be passed to the Assessment Unit. At this juncture it is appropriate to review the program objectives, design and data series. The specific objectives of the program were to provide information on the status of the fish community in the Bay of Quinte and to provide biological information that would allow us to make predictions about impacts of stresses to this fish community. Walleye as both the keystone predator and the most sought after species would have the highest priority in this program.

In the Bay of Quinte in recent years, an extensive mark-recapture program for walleye has provided population estimates (Bowlby and Mathers 1989) that can be used to test the relationship between index catches and population size. If this relationship exists then the index catches would provide a method of estimating historical walleye populations. The purpose of this study was to: i) evaluate walleye catches in summer months to determine the optimum period for index gill net sampling of walleye in the Bay of Quinte, and ii) test the relationship between walleye index gill net catches and walleye population estimates in the Bay of Quinte.

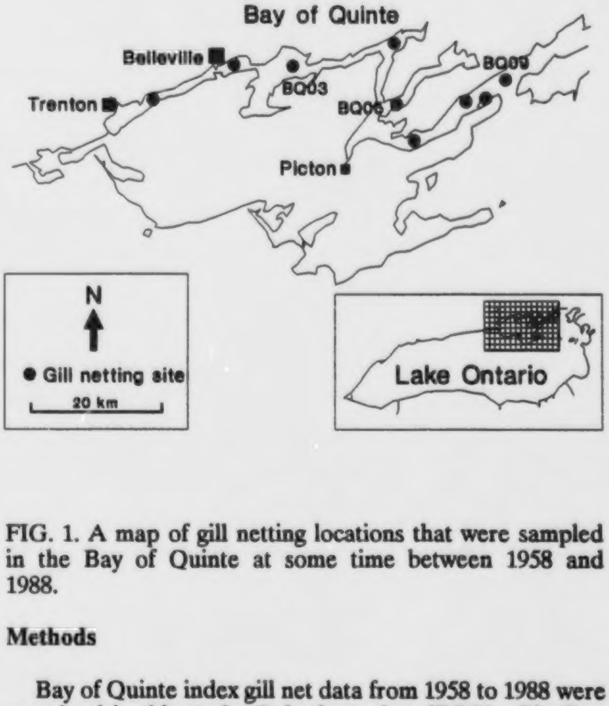

FIG. 1. A map of gill netting locations that were sampled in the Bay of Quinte at some time between 1958 and 1988.

Methods

Bay of Quinte index gill net data from 1958 to 1988 were examined in this study. Only three sites (BQ03 - Big Bay, BQ05 - Hay Bay, and BQ09 - Conway) have been sampled since 1981 and these were the only sites with sufficient overlap in time with the population estimates to be useful for this study. However, BQ09 was rejected at the outset on the basis of inconsistent practice in setting the gear. At BQ09 the nets were set across steep contours and so some panels sampled above the thermocline while others sampled below. BQ05 was sampled continuously from 1958 to 1988, except 1966. BQ03 was sampled continuously from 1972 to 1988, except 1985. Only samples from June, July, and August were examined here. Graded mesh series of gillnets (3.81 cm to 12.7 cm by 1.27 cm intervals) were set for one night of effort. Hurley (1987) provides more detail of the net design and sampling. Catches are reported as the catch of a standard gill net composed of 100 m of each mesh.

Population data were presented by Bowlby et al. (1990) and they based their estimates on forecast or back cast of age-specific 1987 Jolly-Seber population estimates using a total annual mortality of 25% for 2 yr old walleye and 40% for adult fish.

Two indices of walleye year-class strength were developed from the index gill net catches for comparison with population data. Analysis was done on a year-class (cohort) basis using ages 2 to 5 inclusive. The summation index was simply the sum of the catch/effort of ages 2 to 5 of a year-class. The regression index was the year-class specific intercept of a regression of age *vs* catch/effort (i.e. a catch curve) using ages 2 to 5 and assuming that the slope was common for the 1972 to 1984 year-classes (using ANCOVA).

Results

Monthly Differences in Walleye Catch

Monthly catch curves for the combined year-classes from 1972 to 1984 indicate that older fish decline in the catch through the summer (Fig. 2). Two-yr-olds increase in the catch from June to July and then decline in August, while 1-yr-olds increase in the catch through the summer (Fig. 2). Indications from other sources (Bowlby et al. 1990) suggest that these declines are due to migration of older fish to Lake Ontario, and harvest of younger fish by anglers. Those fish that increase in the catch through time may increase in catchability in gillnets due to growth or alternatively may shift in habitat through the summer.

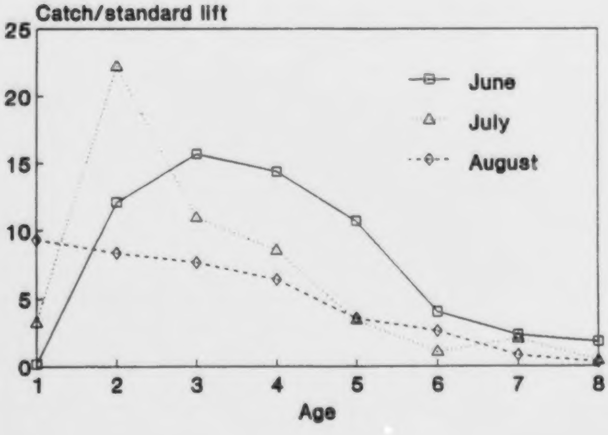

FIG. 2. Composite catch curves for walleye at sites BQ03 and BQ05 in the Bay of Quinte for year-classes from 1972 to 1984.

Walleye Gill Net Catch - Population Relationships

Indices from the summation of catch/effort data and regression analysis were developed using both sites or only BQ05 and with all June, July and August combined, or only July. Data from BQ05 was done separately because that data series has a longer trend through time. Summation and regression indices were not significantly related to the 2-yr-old population using BQ05 only. The summation index was significantly related to the 2-yr-old population for all months combined ($p=0.04$), and the regression index was significantly related to the 2-yr-old population for July ($p=0.05$) and all months combined ($p=0.03$). However, none of these indices explained more than 48% of the variation in the 2-yr-old population (Fig. 3).

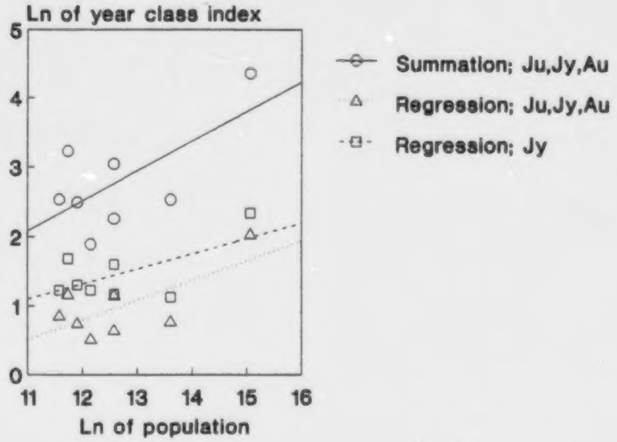

FIG. 3. Indices of walleye year-class strength (see text) and walleye population of that year-class as 2-yr-olds in the Bay of Quinte for year-classes 1977 to 1984.

Discussion

July appears to be the best summer month to sample the Bay of Quinte with gill nets if the sampling proram is confined to a single month. This corresponds closely with our Nearshore Index Gill Netting Program (Bowlby 1990) in Lake Ontario and would therefore provide a more complete "snapshot" of fish distribution and abundance across different habitats. June would certainly provide better catches of larger walleye (Fig. 2), but July provides a better indicator of alewife populations spawning in the Bay of Quinte (Ridgway et al. 1990). Alewife have been suggested as a possible influence on walleye recruitment (Bowlby et al. 1990), and appropriate data should be collected to test this hypothesis.

The Hay Bay site (BQ05) suffers from variable thermocline depth as a result of internal seiches (D. A. Hurley, pers. comm.). Samples from this site can be representative of either the warmwater or coldwater communities (D. A. Hurley, pers. comm.). Perhaps this is the reason that it is such a poor index of walleye populations. This site should be transformed into a depth stratified site like those in the Nearshore Index Gill Netting program. As well, some of the sites that were dropped in 1981 (Fig. 1) should be picked up again for a more complete survey. Further analysis of the data from these sites is required to determine which sites should be picked. The sample size that is required is currently being examined by D. A. Hurley, OMNR.

The 2-yr-old walleye population in the Bay of Quinte can be predicted from index gill net catches of the same year-class for ages 2 to 5. Although the precision is low, this method provides an alternative to check against trawling and modelling predictions of walleye populations in the Bay of Quinte. Some of the suggested changes in the index program design should improve this precision.

Acknowledgements

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Smelt Abundance And Growth In Western Lake Ontario

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The abundance of smelt in western Lake Ontario over the years 1981-89 is estimated at between 0.4 and 1.9 billion. The yearling population cycles with peaks every 2 to 3 yr. The yearling population during 1989 was estimated at 363 million fish. This is low relative to 1988 and 1987; however, the general trend (since 1981) is for increasing abundance of yearlings. In general, the yearling abundance in U.S. waters is similar to the abundance in the western end, however, during 1989 U.S. abundance was 233% of the western end abundance. The adult population (aged 2 yr and older) has stayed relatively constant since 1981 and adult mortality rates, although variable, do not show any consistent decline. Growth of smelt in 1988 and 1989 was slow relative to the early 1980s but faster than smelt observed in U.S. waters of Lake Ontario.

Recommendations:

1. Continue to use bottom trawls to monitor smelt and develop a program to monitor alewife in the western end of Lake Ontario.
2. Document the diet of smelt in western Lake Ontario.
3. Continue to develop forage fish stock assessment techniques for central Lake Ontario (Toronto to Brighton).
4. Consider expanding the eastern basin trawling program to include samples in the shallower waters during June.
5. Collaborate with American biologists to reconcile differences in methodology such as aging and depth stratification, and confirm the observed differences in growth and abundance.
6. Review data from OMNR salmonid diet surveys done in 1983-85 to test the hypothesis that salmonid predation on smelt increased in 1984 when the abundance of large alewife was reduced.

Introduction

Rainbow smelt (*Osmerus mordax*) first became abundant in the Lake Ontario fishery in the late 1930s (Christie 1972) and formed the basis of a commercial fishery with annual catches of up to 296,000 lb (Baldwin et al. 1979). The commercial fishery for smelt in Lake Ontario has almost completely disappeared, however, smelt remain an important fish species in Lake Ontario due to the their abundance in the diets of other fish species. Smelt were the second most important prey item of salmonids sampled in both western (Wismer 1983) and U.S. waters of Lake Ontario (Brandt 1986). Effective and ecologically sound management of the Lake Ontario fisheries resource requires that the status of smelt stocks be assessed.

In 1978 the U.S. Fish and Wildlife Service (USFWS) initiated a spring bottom trawl sampling program to assess abundance of smelt and alewife in U.S. waters (O'Gorman et al. 1989). Beginning in 1981, smelt were sampled from bottom trawls in Canadian waters during juvenile lake trout assessment (Elrod et al. 1986) conducted jointly in August by the USFWS, New York Department of Environmental Conservation (NYDEC), and Ontario Ministry of Natural Resources (OMNR). Cooperative spring (June) bottom trawling for smelt in Canadian waters, independent of the juvenile lake trout assessment, began in 1986.

The purpose of this report is to update yearling abundance, adult abundance and growth of smelt in Canadian waters of western Lake Ontario; compare these data to information from the U.S. bottom trawling from 1981-89; and discuss factors affecting abundance, mortality and growth.

Methods for Fish Sampling and Abundance Calculations

In early August of 1981-85 the USFWS Research Vessel Kaho bottom trawled along three principal transects in western Lake Ontario; Niagara, Hamilton, and Toronto (Fig. 1). At each site, trawling was done at 5 m depth intervals starting at 15 m to 20 m to a maximum of 55 m. A severe storm during the western Lake Ontario trawling in 1983 drastically altered local smelt distributions (Stewart and Oliver 1989). Therefore 1983 western Lake Ontario data were not used.

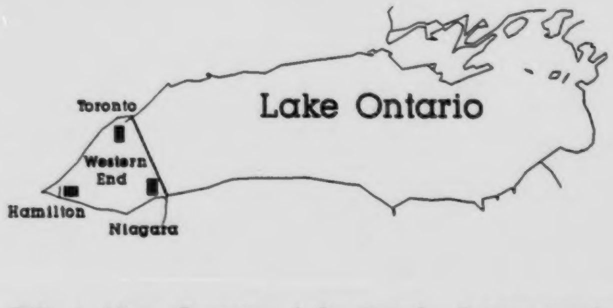

FIG. 1. Map of western Lake Ontario. Bottom trawls were taken within cross-hatched areas.

From 1986-89 sampling was conducted in June at approximately the same locations with the addition of an 8 m site and several sites deeper than 55 m. To accommodate differences in sampling depths among years, we derived estimates of abundance for bottom areas common to all years surveyed (10 m to 50 m). Catches were stratified into bottom areas of 10 m to 20 m, 20 m to 30 m, 30 m to 40 m and 40 m to 50 m. Each year's abundance was the summation over all areas of the average catch/10 min tow in each depth stratum times the number of hectares in each stratum, divided by the area trawled (0.73 ha/10 min tow). This calculation is slightly different from previous reports since in the past it was assumed that a 10 min tow of the bottom trawl swept an area of 0.5 ha (O'Gorman et al. 1989). All the population estimates presented here have used the updated method and are not directly comparable to previous year's reports.

Methods for Age Composition and Growth of Smelt

A random sample of smelt were measured for length from each depth contour sampled. Length, weight, sex, and aging material were taken from a length stratified subsample of approximately 200-400 individuals per yr. Fish were aged by scales from 1981-85, and from pectoral fin ray sections from 1986-89. No fish were aged from the sampling in 1984, so an age-length key determined from data collected in combined 1983, 1985, and 1986 were used to estimate age composition in 1984.

Population length frequency distributions were derived by combining length samples, weighted by catch-per-10 min trawl, for each depth strata separately. A standard age-length key was then applied to determine the age composition at each depth strata. Ages were then weighted by the area of the depth strata and the area trawled, then the depth strata were combined, producing population estimates for each age group.

Recruitment to Gear

A catch curve for the 10 m to 50 m depth strata in western Lake Ontario was constructed from the average catch at age for 1981 to 1989, excluding the 1983 data (Fig. 2). This curve suggests that the smelt are not fully recruited to the gear until age 3. Therefore mortality estimates for this data set will be restricted to fish aged 3 yr and older.

Total length distributions of fish caught in the various depth strata suggests that younger (smaller) fish are found at shallower depths (Fig. 3). Since size (and age) of fish are not evenly distributed across depth strata, age specific population estimates should be made separately for each depth strata (see methods). Current abundance estimates use data from trawls in 10 m to 50 m depth, this finding suggests that future analysis should make use of data from the 8 m depth to allow a more complete assessment of yearling abundance.

Total Abundance of Smelt

The 1989 smelt population in western Lake Ontario is estimated at 599,981,176 fish age 1 yr and older (10 m to 50 m depth)(Fig 4). Stewart and Oliver (1989) observed that in general the abundance of smelt in U.S. waters of Lake Ontario and western Lake Ontario are very similar (Fig. 5). During 1989, the abundance of smelt in U.S. waters was 1.112 billion fish (1,621 fish/tons) (O'Gorman et al. 1990) which is 185% of that observed in the western end.

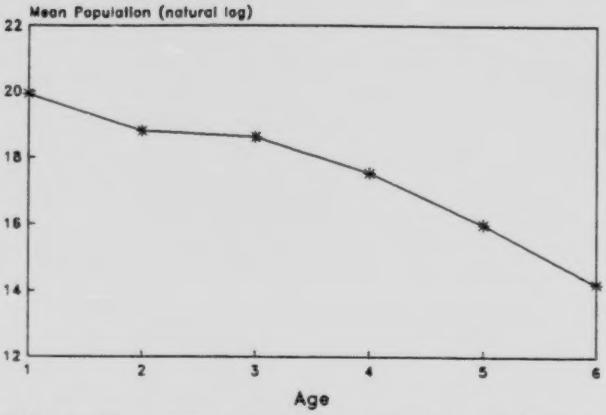

FIG. 2. The average abundance (natural logarithm) of each age group caught in trawls (10 m to 50 m water depth) in western Lake Ontario 1981 to 1989 (excluding 1983).

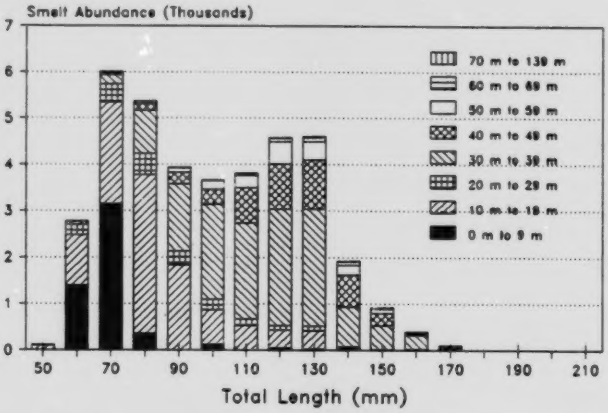

FIG. 3. Total length distribution of smelt in the various depth strata sampled during the 1989 bottom trawl program in western Lake Ontario.

Data from the trawling program conducted in eastern basin of Lake Ontario (Casselman et al. 1989) shows some trends in smelt abundance similar to western Lake Ontario and U.S. waters (Fig. 5). However, overall the eastern basin was not correlated with either western end ($r^2 = 0.066$, d.f. = 6) or with U.S. smelt abundance ($r^2 = 0.040$, d.f. = 9). The eastern basin program was not designed to monitor smelt abundance and trawling was only conducted in deep water (six tows in 26 m to 38 m). Trawling in shallower water appears to be important to provide representative catches of smaller fish (Fig. 3). Expansion of the eastern basin trawling program to include shallower waters during the month of June should provide an estimate of smelt population abundance for these waters.

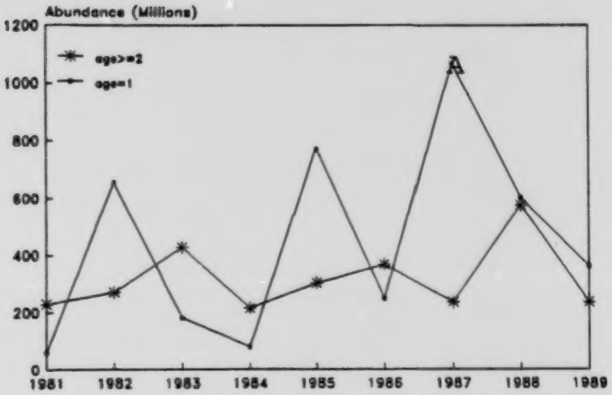

FIG. 4. Abundances of smelt, by age group, available to bottom trawls in western Lake Ontario areas of 10 m to 50 m depth. Age structure data for 1984 are estimated from age data in proximate years. Catch data for 1983 are estimated from data in proximate years (see methods).

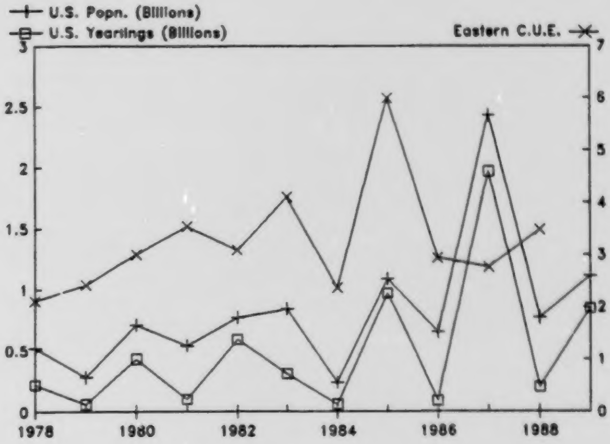

FIG. 5. Smelt catch-per-standard trawl in eastern Lake Ontario. Also shown are the smelt abundance estimates for yearlings and fish aged 2 yr and older in U.S. waters of Lake Ontario. U.S. data from O'Gorman et al. (1990).

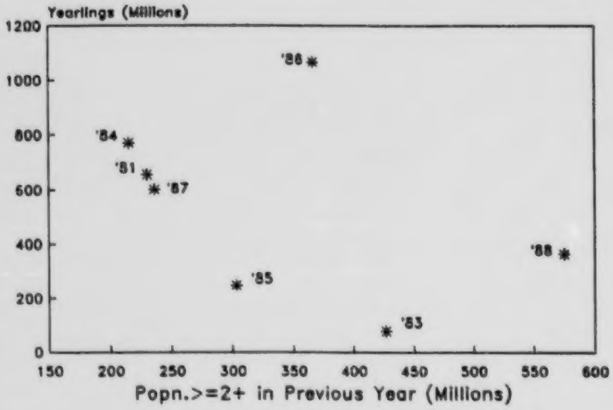

FIG. 6. The relationship between parental stock (aged 2 yr and older) and recruits (as shown by yearlings in the following year). Data are from trawls (10 m to 50 m water depth) in western Lake Ontario, 1981 to 1989. The year-class of the smelt is shown beside each observation.

Expansion of the Eastern Basin program would get us nearer to goal of a lakewide estimates of forage fish abundance (Stewart and Oliver 1989). A method of sampling the waters between Toronto and Brighton is being developed (Schaner and Stewart 1989) and we recommend that work towards this goal be continued.

Yearling Abundance and Mortality

Abundance of smelt, in western Lake Ontario, cycles with peaks every 2 or 3 yr (Fig. 4). Cyclical recruitment of yearling smelt in western Lake Ontario accounts for the observed periodicity in overall abundance, since yearling smelt account for up to 82% of the total population sampled. The estimate of yearlings for 1989 was 362,623,816 (10 m to 50 m water depth) which is low relative to recent years. However, if the peak years of the cycle (1982, 1985, and 1987) are examined alone, the abundance of yearling smelt appears to be increasing.

In the past abundance of yearling smelt in the western end has been strongly correlated with abundance in U.S. waters (Stewart and Oliver 1989). During 1989, the abundance of yearling smelt in U.S. waters was 0.846 billion fish (1,234 yearlings/tons) (O'Gorman et al. 1990) which is 233% of than observed in the western end. It is unclear, at this time, why the yearling abundance is different in these two bodies of water during 1989.

The cyclic nature of yearling smelt recruitment in Lake Ontario has been attributed to the abundance of the previous smelt year-class and also to alewife abundance (O'Gorman et al. 1987). In other bodies of water, the abundance of the previous smelt year class has often been implicated (Regier et al. 1969; Evans and Waring 1987; Henderson and Nepszy 1989). Henderson and Nepszy (1989) found that an index of survival of smelt, from hatch to the following spring, was inversely related to the abundance of yearling smelt in the year of hatch. We could find no single biotic parameter which explained significant variation in yearling abundance or yearling survival. No consistent stock-recruitment relationship is apparent (Fig. 6). Yearling abundance was not correlated with abundance of yearling smelt in the previous year ($r^2=0.093$, d.f. = 6), or to abundance of yearlings and 2 yr olds in the previous year ($r^2=0.026$, d.f. = 6). An index of survival from hatch to yearling stage (calculated as yearlings at time T + 1 divided by parental stock size at time T) was unrelated to yearling abundance during the year of hatch ($r^2=0.145$, d.f. = 6).

Catches of YOY smelt in Long Point Bay of Lake Erie (anon. 1989) are correlated ($r^2=0.604$, d.f. = 6, $p=0.023$) with smelt year-class strength observed in western Lake Ontario (Fig. 7). This relationship suggests that either regional weather patterns control year-class strength in both lakes, or

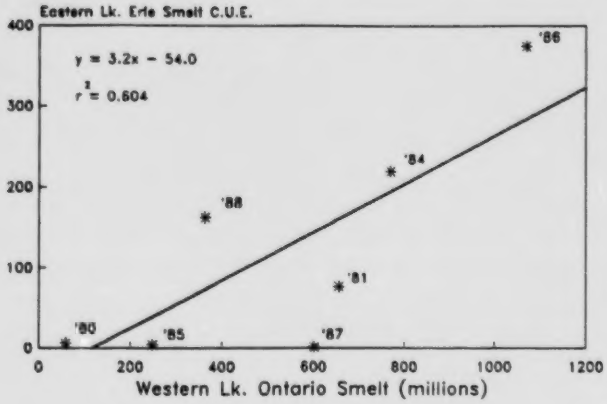

FIG. 7. The relationship between smelt year-class strength in Lake Erie and smelt year-class strength in western Lake Ontario. Year-class strength in Lake Erie is shown by catch of YOY in the Long Point Bay Nearshore Outer Bay trawling project (anon. 1989). The western Lake Ontario year-class strength is shown by yearling abundance in the following year as determined from trawl catches (10 m to 50 m water depth). The year-class of the smelt is shown beside each observation.

that large numbers of fry from Lake Erie enter Lake Ontario. Although these hypothesis seem far fetched, the importance of knowing factors which control smelt year class strength suggests further investigation is warranted. The importance of regional patterns could be tested by examining smelt year class strength in Lake Huron and Lake Superior. The overflow hypothesis could be examined using drift nets in the Niagara River in attempt to catch smelt fry.

Adult Abundance and Mortality

The abundance of adult smelt (aged 2 yr and older) has remained relatively constant since 1981 although, like yearlings, some cycling is apparent (Fig. 4). There is considerable variation between years in the survival estimates for fish aged 3 yr and older (Fig. 8). Survival was calculated by dividing pooled abundance estimates of fish aged 4 yr and older in year T + 1 by the pooled abundance of fish aged 3 yr and older in year T. Survival of fish from 1988 to 1989 is very low (0.152), but there is no clear trend of declining survival over recent years.

O'Gorman et al. (1987) reported that the survival rate of adult smelt was positively related to the abundance of alewife. We were unable to test for this relationship because alewife abundance in western Lake Ontario is not measured. It is interesting to note the poor survival of smelt during 1984-85 when alewife were in low abundance in U.S. waters (O'-Gorman et al. 1987). Decreased survival may have been due to increased predation on smelt by salmonids. We suggest that the salmon diet data from 1983-85 be analyzed to look for increased occurrence of smelt in salmon stomachs during 1984. Henderson and Nepszy (1989) found a positive relationship between adult smelt mortality and abundance of the parental stock in Lake Erie. This relationship for western Lake Ontario was not significant ($r^2 = 0.256$, d.f. = 4, p = 0.306, Fig. 9).

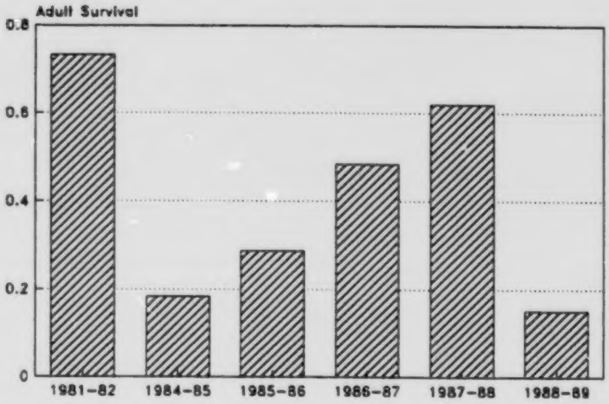

FIG. 8. The survival rate of adults captured in trawls (10 m to 50 m water depth) in western Lake Ontario. Survival was calculated as abundance of ages 4 to 6 in year T + 1 divided by abundance of ages 3 to 6 in year T.

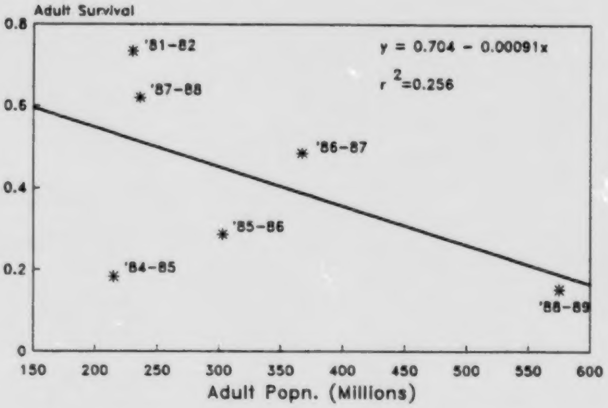

FIG. 9. Adult survival rate as a function of the adult population (2 year olds and older) in western Lake Ontario, 1981 to 1989 (excluding 1983 data). Survival was calculated as abundance of ages 4 to 6 in year T + 1 divided by abundance of ages 3 to 6 in year T.

The abundance of large smelt (= 150 mm), relative to the abundance of small smelt, has declined since 1984 (Fig. 10). This was also found in U.S. waters of Lake Ontario and O'-Gorman et al. (1989) attributed this to: (1) high mortality of smelt (presumably due to predation), (2) small size of the 1983 and 1985 year-classes, and most importantly, (3) slow growth of young smelt in recent years. Stewart and Oliver (1989) suggested that increased abundance of salmonids since 1980 may have contributed to the recent decline in the number of large smelt. The relatively high adult smelt sur-

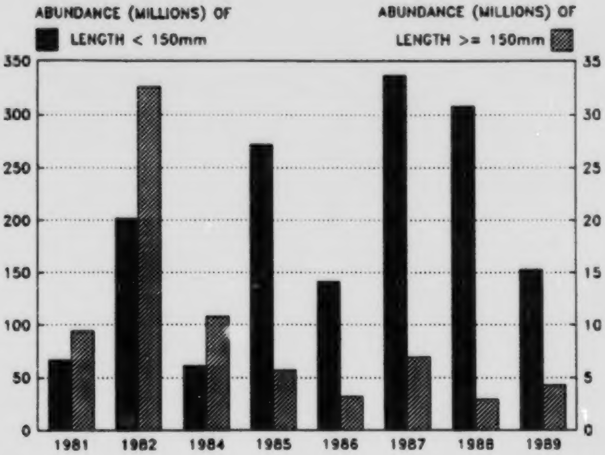

FIG. 10. The estimated abundance of large smelt (total length = 150 mm) and small smelt (total length 150 mm) for 10 m to 50 m water depth in the western end of Lake Ontario.

vival rates observed in 1986-87 and 1987-88 (Fig. 8) and the absence of a general decline in adult abundance (Fig. 4) suggest that salmonids abundance is not the single factor controlling large smelt numbers. Slower growth seems the most likely explanation.

Growth of Smelt

Smelt observed in western Lake Ontario during 1988 and 1989 are not as large as those observed in the early 1980's (Fig. 11). Growth of smelt in U.S. waters of Lake Ontario has also declined in recent years. O'Gorman et al. (1987) attributed slower growth of young smelt to recovery of the alewife population from the 1976-77 die-off. Increased abundance of alewife is thought to have reduced the zooplankton available to yearling smelt as food. It seems likely that the decline in the size of the older age groups is due to poor growth as YOY and yearlings. Alternatively, benthic invertebrates, which older smelt feed on, may have become less abundant.

The growth of smelt in western Lake Ontario is more rapid than observed in U.S. waters (Fig. 11). This relationship has been observed in the past (Stewart and Oliver 1989) and has been particularly strong for yearling and two year old smelt. It was hypothesized that this may be due to: (1) reduced competition with alewife or (2) higher zooplankton biomass in western Lake Ontario relative to U.S. waters (Stewart and Oliver 1989). We were unable to test the first of these hypothesis because of the lack of alewife abundance information. The second hypothesis is not supported by Borgmann et al. (1984) who found that of the waters tested in Lake Ontario the western end was the lowest in total epilimnetic zooplankton production. This was attributed to colder water temperatures caused by upwelling. Stewart and Oliver's (1989) second hypothesis assumes that yearling smelt feed primarily on Cladocera and Copepoda as has been observed in Lake Erie (Henderson and Nepszy 1989). It remains possible that zooplankton is not the most important food for yearling smelt in the western end. We suggest that the food of yearling smelt be documented.

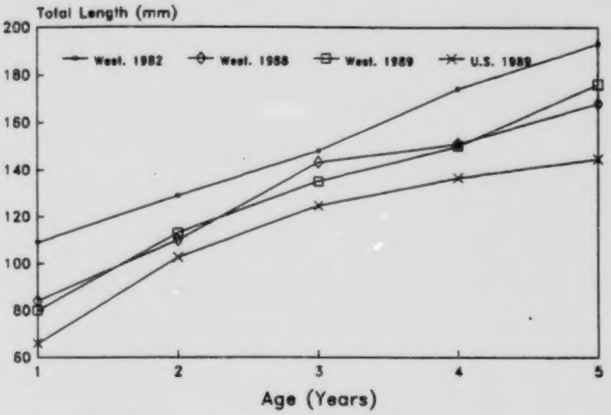

FIG. 11. Mean size of smelt ages 1 to 5 in western and U.S. waters of Lake Ontario. U.S. data from O'Gorman et al. (1990).

Acknowledgments

Thanks to the USFWS and NYDEC for their assistance with the bottom trawling. Thanks to Linda Balsillie for publishing and Carol Ward for copy editing this manuscript.

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Status of Lake Whitefish Populations in Eastern Lake Ontario

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Lake Ontario Fisheries Unit, 1989 Annual Report, LOA 90.1 (Chapter 5)

The whitefish population of the Bay of Quinte stock in 1988 was estimated to be 810,515. This estimate is 3.22 times higher than a similar 1987 estimate and is consistent with recent catches in index gill nets and trawls. The index gill net catches were slightly lower in 1989 than 1988 because of a weak 1988 year-class. High catches of whitefish were observed by LOFU in the commercial walleye trapnet fishery, and this suggests that a viable trapnet fishery targeting whitefish may be feasible for some fishermen. Some other commercial trapnet fishermen might be able to use whitefish as part of a mixed species fishery. Zebra mussels are likely to affect whitefish spawning grounds in the Bay of Quinte and Lake Ontario.

Recommendations

1. When stock discrimation techniques are developed, a whitefish population model should be developed by consolidating the index and mark-recapture data.
2. To assess the impact of zebra mussels on whitefish egg viability it is imperative to conduct in situ studies in 1990 for pre-impact comparisons.

Introduction

Lake whitefish populations have resurged in Lake Ontario in the past decade, but have not shown any tendency toward some stabilized level (Bowlby 1989). Historically, the Bay of Quinte stock contributed the greatest number of whitefish to the commercial fishery (Christie 1973). This situation appears to be returning with the resurgence of the Bay of Quinte stock. Populations declined during the late 1960s after about 35 years of relatively stable catches in the commercial fishery. This reports updates the status of whitefish populations in the Canadian part of eastern Lake Ontario.

Methods

Data in this report come from the Nearshore Index Gill Net Program (Bowlby 1990), the Research Lake Gill Net Program (Hurley 1987), and the Walleye Mark-Recapture Program (Mathers and Bowlby 1990). Commercial catch sampling was discontinued in 1989 for whitefish and harvest estimates are based on commercial fishermen's mandatory catch reports (CF1s).

Results and Discussion

Petersen population estimates of the Bay of Quinte whitefish stock for 1988 are 810,515. This population estimate is for males that are 2 yr and older and females that are 3 yr and older in 1988. These fish were virtually all mature in 1989 and the recaptures are based on the spawning population. Although, like virtually all mark-recapture studies, some assumptions of the Petersen model are violated (Ricker 1975), this interpretation appears to be the least offensive to these assumptions and likely provides a conservative estimate of the population as defined above. The 1988 population estimate is 3.22 times higher than the 1987 estimate (Fig. 1). Substantial numbers of males of the strong 1986 year-class were recruited into the spawning population in 1989. Note that for the following two reasons this is not an estimate of the fishable stock in 1989. First, the estimate is for 1988 (the year of marking), and this population would be subject to mortality during the subsequent year. Second, this estimate does not include any female whitefish from the 1986 year-class, and these fish would be vulnerable in winter 1989-90 to the gill net fishery in Quota Zone 4 (Adolphus Reach/North Channel), but not to the hoop net fishery in Quota Zone 3 (middle and upper Bay of Quinte) during fall 1989.

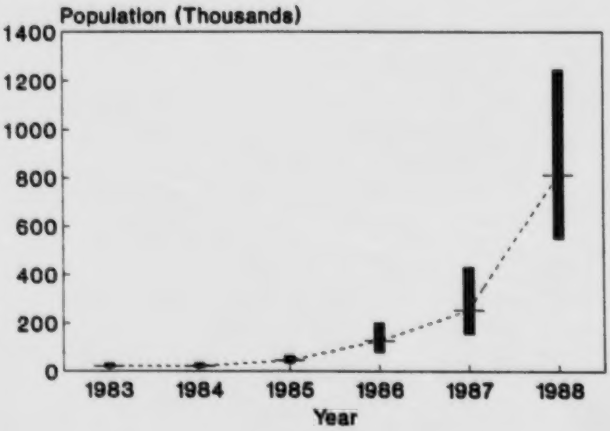

FIG. 1. Population of Bay of Quinte stock of lake whitefish based on Petersen estimates.

We expect the Bay of Quinte whitefish population estimate to increase again for 1989. Based on the abundance of young-of-the-year (YOY) in trawls, strong 1986 and 1987 year-classes are expected (Bowlby 1989), and portions of these year-classes are expected to be recruited into this population. No population estimates were made for the lake stock.

Index gill nets in the Kingston basin of Lake Ontario continued to catch large numbers of whitefish, but on the whole showed a slight decline (Figs. 2 and 3). This pattern is consistent with the observed pattern of catches of YOY in research trawls (Bowlby 1989) indicating strong year-classes in 1986 and 1987 but a weak year-class in 1988. Research trawls were not done in 1989 and so we have no early indication of whitefish year-class strength in 1989. The gill nets are a combined index for the lake stock and the Bay of Quinte Stock. Work on stock identification using otoliths and scales is progressing well and the technique appears to be quite promising for discriminating these two stocks in the index catches (John Casselman, pers. comm.). Once this research and related research on scales are completed, a more detailed analysis on the age structure of the these two stocks should be performed.

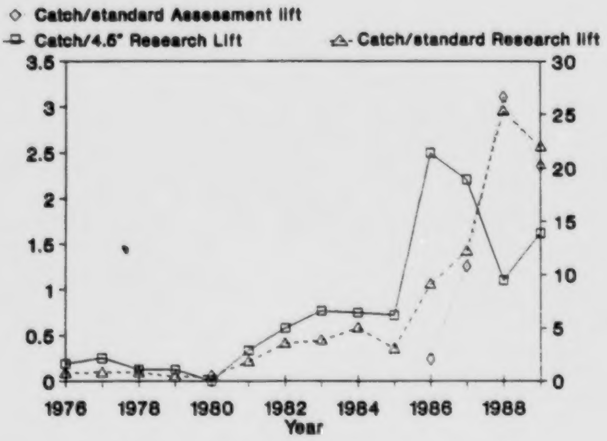

FIG. 2. Catches of lake whitefish in index gill nets in the Kingston basin of Lake Ontario.

The commercial whitefish fishery was not monitored in 1989. However, some whitefish were observed in the onboard sampling of the commercial walleye fishery. One trapnet fisherman had great success with whitefish in the Kingston basin of Lake Ontario during the walleye trapnet fishery, showing that the "window" for the whitefish fishery might be expanded beyond November. In three lifts of one trapnet we observed 582 kg of whitefish harvested, certainly enough catch-per-lift to provide a fishery targeted specifically towards whitefish. Other walleye trapnet fisherman caught smaller numbers of whitefish. Two groups of fishermen west of Prince Edward County averaged 16 and 23 kg (35 and 50 lb) of whitefish per-lifting-day. Although this could not be considered a viable whitefish fishery, it does contribute to the success of a multi-species trapnet fishery.

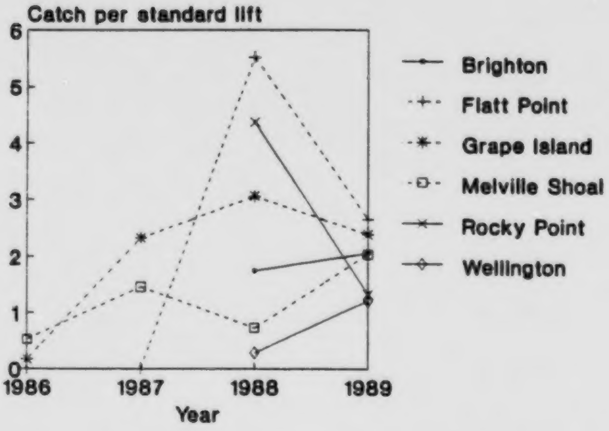

FIG. 3. Catches of lake whitefish in index gill nets in Lake Ontario.

Currently, our population assessment relies on a combination of mark- recapture and index fishing. We have been unable to relate the two methods because of mixing of stocks at the index fishing locations. Accordingly, we must assign quotas for the following year based on population estimates from the previous year. To make timely estimates of populations and potential yield, it is essential that we consolidate these approaches into a model similar to the Walleye Management Model (Bowlby and Mathers 1989). The building of this model should increase in priority as soon as stock identification techniques are established.

One concern for the ongoing rehabilitation of whitefish is the inevitable invasion of zebra mussels from Lake Erie. These mussels are likely to use whitefish spawning habitat, making it less suitable for whitefish (except in rivers). If we are to properly assess the impact of zebra mussels on whitefish spawning and egg viability then it is imperative to conduct in situ studies in 1990. Diving ducks are the only agent that appears to control mussels to any extent in Europe (R. Griffiths, OME, pers. comm.), and so consideration might be made to protect diving ducks in important spawning areas for whitefish and other important fish species.

Acknowledgements

I thank the Operations staff at LOFU for collecting the data from various programs and the Systems staff for timely data entry and verification. Tom Stewart and Phil Smith commented on a previous draft. Linda Balsillie courageously transformed this text into Ventura format.

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Nearshore Index Gill Nets, 1989

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This report provides an update of the status of yellow perch, lake herring, bullheads, and white perch in eastern Lake Ontario. In general these species show relatively little change in catch compared with 1988 catches.

Recommendation

1. Discontinue sampling at 2.5 m to avoid moss in nets.

Introduction

This report provides an update of the status of yellow perch, lake herring, bullheads, and white perch caught in gill nets in eastern Lake Ontario, and follows Mathers (1989). The objectives of the project are to provide: i) a consistent index of abundance of fish populations, and ii) biological information on these species.

Methods

Data were collected at 6 depth stratified transects (2.5 - 27.5 m) in eastern Lake Ontario and one single depth site in Lake Ontario near Brighton (Fig.1). Also, data were reported here from the Research Index Gill Net Progam (Hurley 1987) in the Bay of Quinte (Fig. 1). The data were for the most part collected as in other years (Mathers 1989) and the details are given by Bowlby and Mathers (1989).

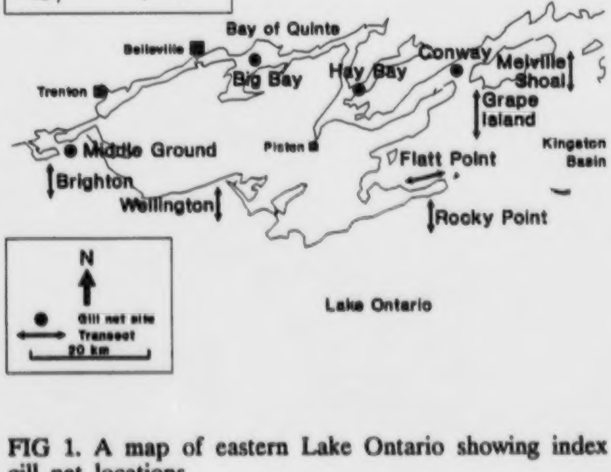

FIG 1. A map of eastern Lake Ontario showing index gill net locations

During 1989, the shallowest depth in the transect (2.5 m) was not sufficiently sampled to include in any analysis because of excessive moss build up in the nets. Accordingly, catches at these transects were presented as the mean of depths from 7.5 to 27.5 m. These analyses are strictly graphical and do not include stastistical control for differences in water temperature (see Mathers 1989), but future analyses should take water temperature into consideration.

Results

Yellow Perch

In general, yellow perch populations in eastern Lake Ontario appear to be stable. In Lake Ontario, yellow perch increased at the three Kingston basin transects and at the Brighton transect (Fig. 2), but declined at the Wellington transect and at Middle Ground (Fig. 3). Catches of marketable size yellow perch were greatest at Grape Island and Melville Shoal (Fig. 4). The loss of marketable size perch at Middle Ground was countered with an increase at the Brighton transect, nearby. Accordingly, our interpretation is that larger yellow perch in this area shifted in habitat between 1988 and 1989. In the Bay of Quinte, yellow perch increased at Big Bay and Hay Bay, but declined at Conway (Fig. 5).

Yellow perch populations in Lake Ontario appears to be controlled by alewife (Abraham 1983; Brandt et al. 1987). The large populations of yellow perch observed in 1980, 1981 and 1986 (Figs. 2 and 3) are consistent with low alewife populations that Casselman et al. (1989) observed in Lake Ontario in the late 1970s and in 1984. Recent increases in yellow perch in the Bay of Quinte are also consistent with recent declines in alewife numbers in the bay (Bowlby et al. 1990).

Lake Herring

Lake herring populations remain low, but stable (Fig. 6). Christie (1973) noted that the decline in lake herring was consistent with the invasion and growth of smelt populations in Lake Ontario. Because smelt abundance remains high we expect relatively little change in lake herring populations. Smelt are less abundant in the Bay of Quinte and whitefish (which are also controlled by smelt) are rebounding there since eutrophication has been reduced. The lack of response of herring to habitat improvements in the bay is puzzling, but suggests that it may be more sensitive to eutrophication or that some other species may control it there.

Bullheads

Bullhead populations appear to be stable in Lake Ontario and the Bay of Quinte (Figs. 7 and 8). However, these nets do not sample good bullhead habitat and may not be good indicators of bullhead populations.

White Perch

White perch populations remain lower at Hay Bay and Conway since their decline in 1978 (Fig. 9). In Big Bay, the population has remained much higher. However, in 1989 the population in Big Bay was at the second lowest level since 1978. Relatively few white perch were caught at the sites in Lake Ontario and are not presented here.

Discussion

The potential importance of alewife or smelt in controlling populations of economically important species such as whitefish, yellow perch, lake herring, and walleye points out the need for greater study of these potential interactions. Some of these species may be benefitting from localized declines of smelt and alewife in the Bay of Quinte. More research is necessary on the impacts of alewife and smelt on the community structure in Lake Ontario.

Acknowledgements

I thank the Operations staff at LOFU for collecting the data from various programs and the Systems staff for timely data entry and verification. Alastair Mathers and Tom Stewart commented on a previous draft. Linda Balsillie courageously transformed this text into Ventura format.

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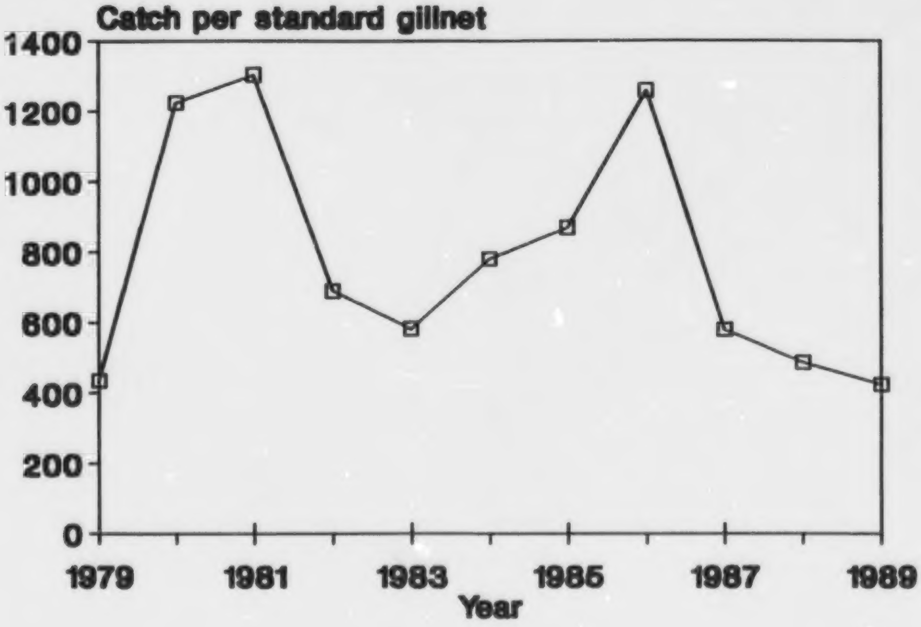


FIG 2. Mean catch of yellow perch in index gill nets at Middle Grounds site during August.

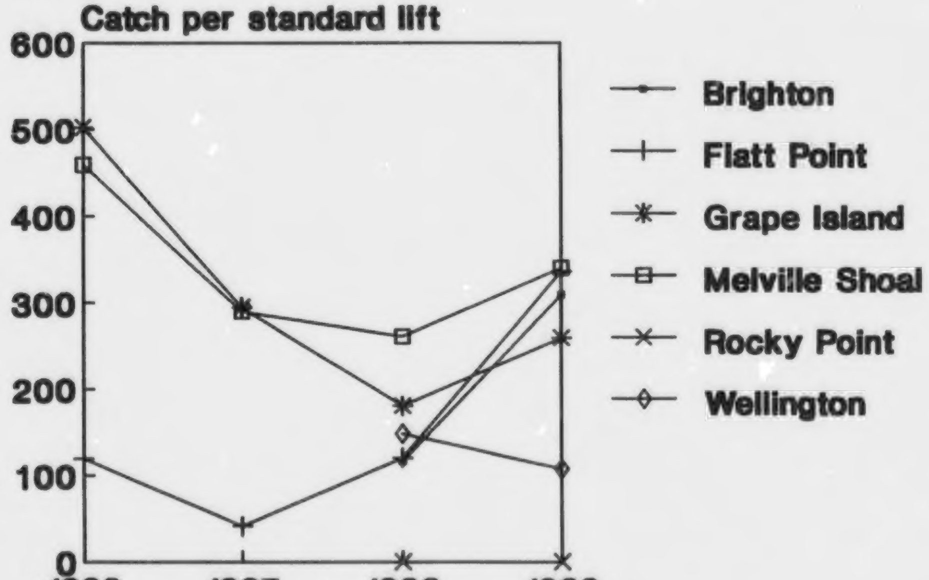
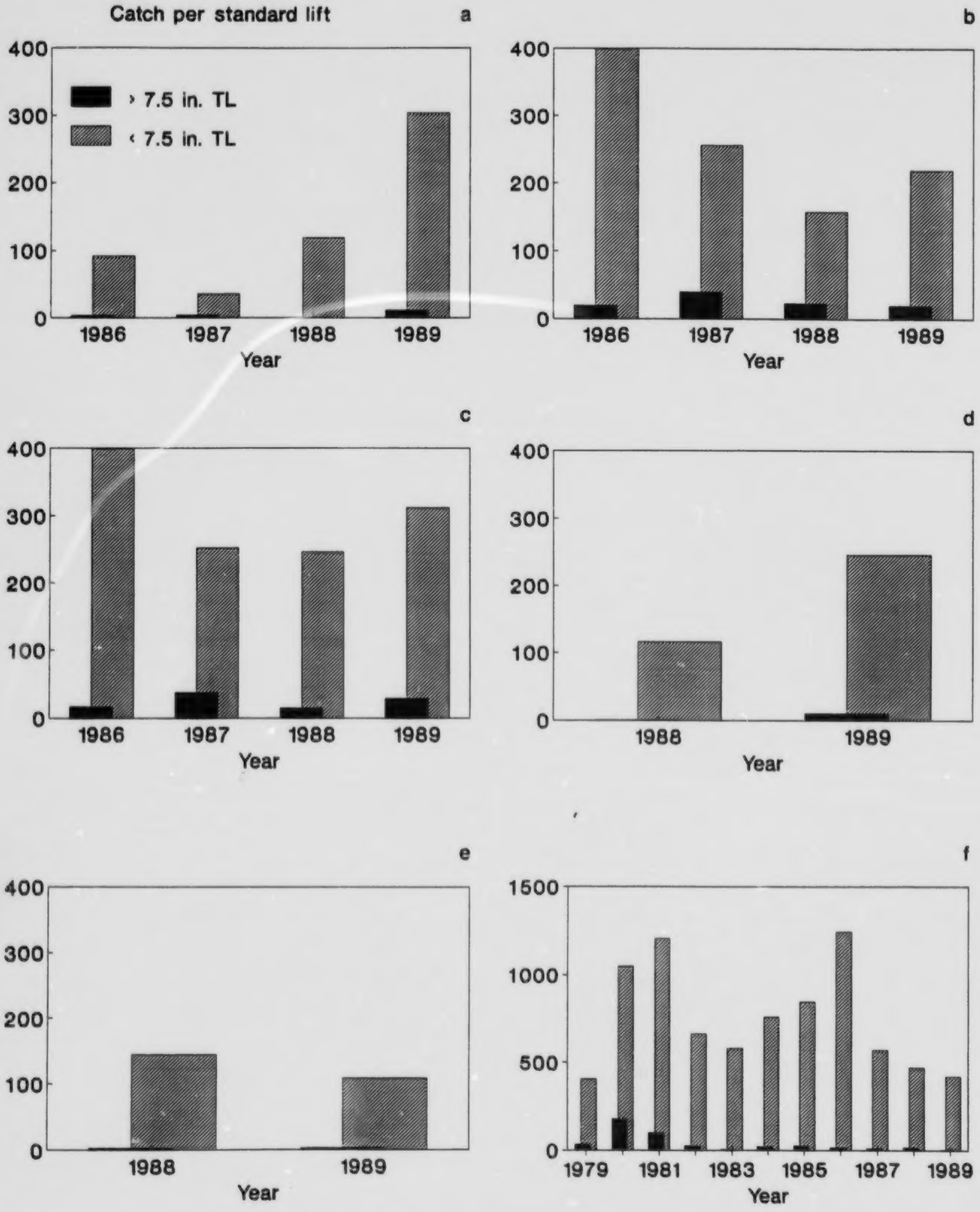


FIG 3. Mean catch of yellow perch at transects in eastern Lake Ontario during July and August.

FIG 4. Mean catch of yellow perch by marketable size class at transects in eastern Lake Ontario during July and August. a - Flatt Point; b - Grape Island; c - Melville Shoal; d - Brighton; e - Wellington; f - Middle Grounds.



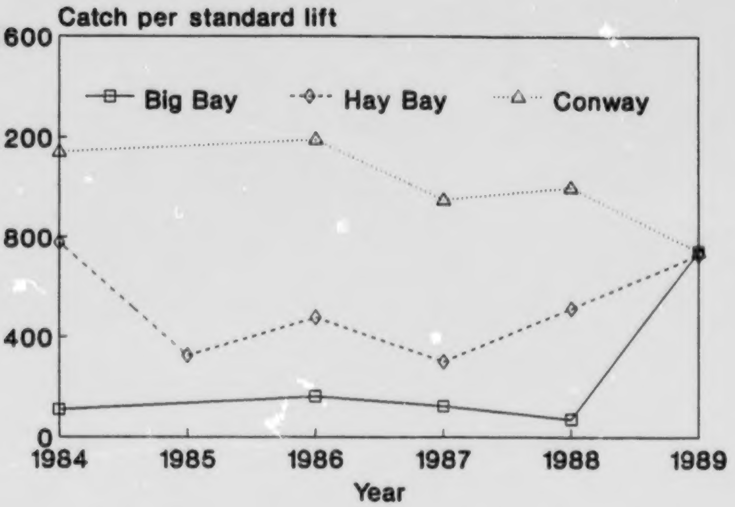


FIG 5. Mean catch of yellow perch in index gill nets at Bay of Quinte sites during June to August.

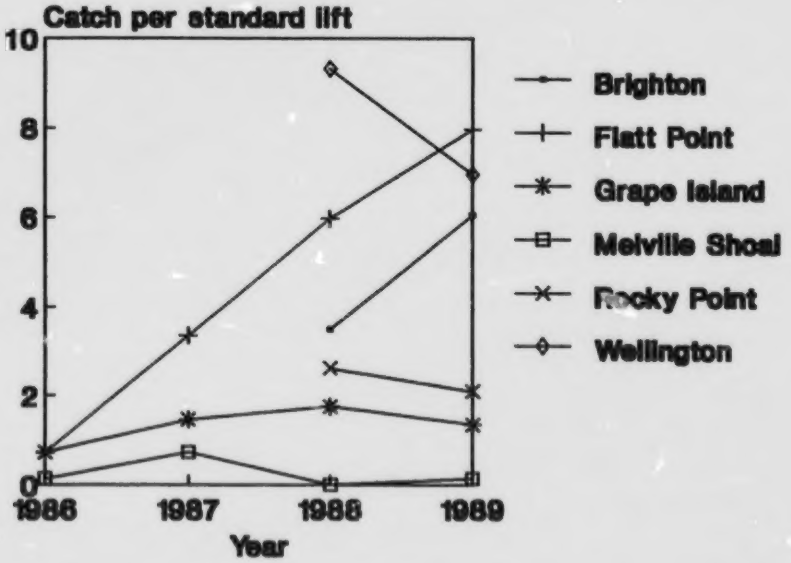


FIG 6. Mean catch of lake herring at transects in eastern Lake Ontario during July and August.

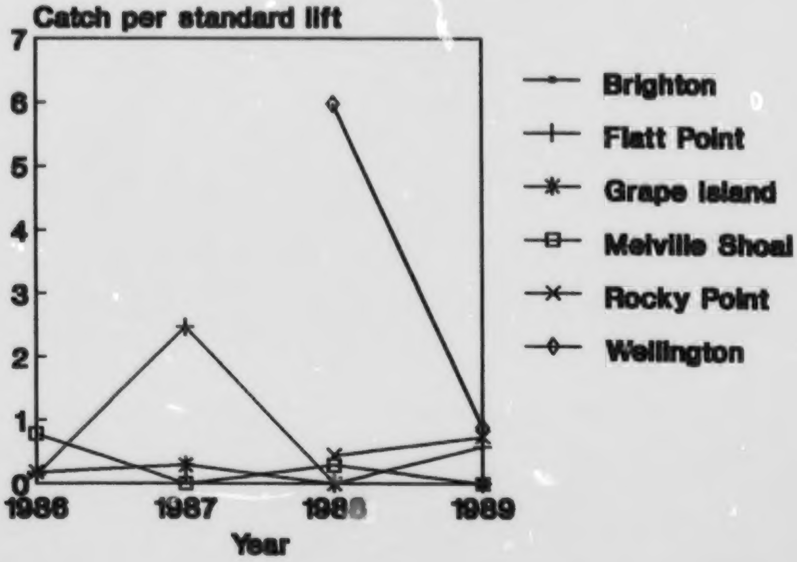


FIG 7. Mean catch of bullhead at transects in eastern Lake Ontario during July and August

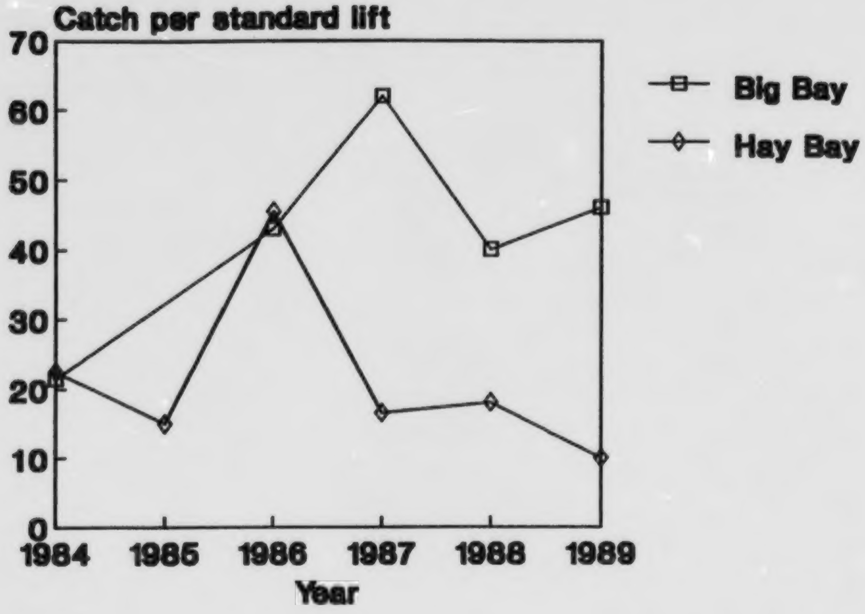


FIG 8. Mean catch of bullhead in index gill nets at Bay of Quinte sites during June to August.

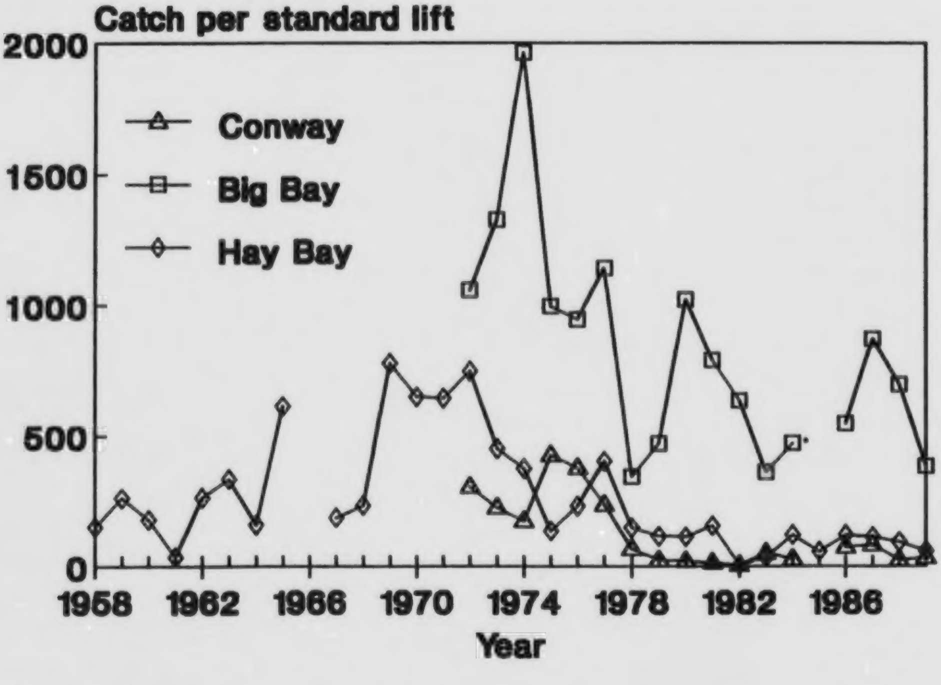


FIG 9. Mean catch of white perch in index gill nets at Bay of Quinte sites during June to August.

Survival, Growth, and Distribution of Stocked Lake Trout: Analysis of Canadian Fin Clip Data.

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Lake Ontario Fisheries Unit, 1989 Annual Report, LOA 90.1 (Chapter 7)

Survival, growth and lakewide distribution of Canadian stocked lake trout are examined and compared to U.S. stocked fish. Survival at age 3 varies with strain and possibly weight at stocking; the survival of Canadian fish matches that of some American strains but is lower than others. Mean length at age 3 is, with one exception, similar among strains, and is not affected by weight at stocking. Most lake trout remain in the area where they were stocked.

Recommendations

1. Maintain the coded wire tagging program in Canadian stocked fish, so that their survival can be monitored, especially at reproductive older ages.
2. Further investigate dispersal, especially seasonal patterns, because it has implications to the lake trout rehabilitation efforts. If lake trout do not disperse, then in order to maintain lakewide distribution, there must be lakewide stocking and/or spawning. Lakewide spawning requires that there be suitable spawning shoals throughout the lake.
3. No recommendations are made concerning the choice of strains to be stocked. This subject will be discussed in the updated Joint Plan for Rehabilitation of Lake Trout in Lake Ontario (in preparation).

Introduction

Fin clips have until recently been used to mark all lake trout stocked by the province of Ontario. Stocked fish were clipped to allow distinction between stocked and possible naturally reproduced fish. The clips were also used to identify strains and stocking locations. This report examines recaptures of clipped fish in order to assess the performance of fish stocked by province in the past.

Methods

Data used in this analysis were collected in the annual lake trout index program, conducted on a cooperative basis by the Ontario Ministry of Natural Resources, New York Department of Environmental Conservation, and the U.S. Fish and Wildlife Service (description in Schneider et al. 1987, Appendix 1). Only data from the last five years (1985-89) were used, because prior to 1985 the program was still developing, and less fishing effort was spent in Canadian waters. Stocking information was obtained from Anon. (1985); Daniels and LeTendre (1987); Stewart and LeTendre (1988).

Survival and growth

Canadian stocked fish were recognized by their fin clip combinations. The clipping scheme was originally devised to allow identification of individual groups of stocked fish throughout their lifetime. Since there are not enough possible clip combinations to allow unique markings for all stocking groups present in the lake at one time, the scheme counted on fish length to resolve identification problems in cases where the same clip combination belongs to two or more groups. Unfortunately, the same combinations were reused too frequently, and with the overlap in lengths between older ages, there were few cases where fish beyond the age of 3 could be assigned to a given stocking group. With older ages mostly unidentifiable, and with statistics on 2-yr olds considered more variable (the fish are just becoming vulnerable to the gillnet), statistics for 3-yr olds were used to compare stocking success.

The identifiable stocking groups were the ones that appeared as distinct modes in length frequency histograms of fish with a given clip. Their numbers, mean length and variability around mean length were estimated from histograms using MIX software (MIX 1988). Only modes that were recognizable by the naked eye were used, and the process involved a great degree of personal judgment. The survival index was calculated as the number of recaptures per 10,000 fish stocked. This simple index was deemed sufficient because the amount of index fishing effort and its distribution around the lake were similar for all five years of data. Survival index and mean total lengths for all identifiable Canadian stocking groups and ages are listed in Table 1.

Statistics on U.S. stocked fish (Clearwater, Jenny, Seneca, Superior and Ontario strains) were used as a comparison to the Canadian fish. The data were collected in the same index program. U.S. agencies have been using coded wire tags to mark stocked fish since 1979, and many stocking groups were, therefore, easily identified in the data set by their codes (summary in Schaner 1990).

Distribution

For the distribution analysis it was, again, necessary to use fin clips to distinguish between stocking groups. The MIX

Table 1. Summary of statistics on Canadian stocked lake trout that could be identified by fin clip

	Stocking		Recapture		
Strain	Number	Indiv. weight(g)	Age	Surviv. index	Mean total length(mm)
Killala	230,175	10.8	3	0.78	508
Killala	97,750	10.8	3	1.64	491
Killala	75,000	11.4	3	2.93	507
Killala	147,576	11.6	3	1.56	520
Killala	142,304	13.0	3	0.91	476
Killala	358,852	21.6	3	1.70	487
Killala	169,750	22.7	3	1.47	511
Killala	160,664	8.7	3	0.68	464
Killala	429,689	15.1	3	0.98	495
Killala	203,662	13.0	3	0.74	518
L.Manitou	184,617	9.7	3	0.60	518
L.Manitou	132,712	16.2	3	2.11	426
L.Manitou	200,043	9.7	4	1.0	572
			5	2.0	648
Superior	90,000	3.8	6	1.0	723
			7	1.22	737
mixed strains (a single stocking)	387,312	7.7	5	2.12	642
			6	2.12	702
			7	1.81	732

method could not be used because the data had to be split by recapture site. This yielded a series of site-specific length frequency histograms each based on too few fish. Results from previous MIX analysis of the whole lake data set, provided age-specific mean lengths and standard deviations of various stocking groups. Therefore, fish were assigned to stocking groups based on fin clips and proximity to a previously recognized peak in the length frequency distribution. Only fish with the appropriate fin clip combination, and measuring within one standard deviation of a previously recognized peak, were assigned to a stocking group. All others were discarded. This rule was conservative, but it insured that the majority of assignments were correct.

Results and Discussion

Survival and growth

Survival of the Killala and Lake Manitou fish at age 3 is comparable to the lower range of survival values found in the U.S. stocked strains (Fig. 1). The Canadian fish are comparable to Clearwater Lake, Jenny Lake and Seneca fish, but less successful than Ontario or Superior fish. However, the Canadian fish were smaller at stocking than any of the U.S. strains. The question then is whether lower survival is caused by strain, stocking size, or both.

Within all strains, there is a weak positive correlation between weight at stocking and survival. It is significantly positive ($P < 0.10$) in three of the six strains where it could be tested. This indicates that size at stocking plays some role in survival. Survival also varies among strains. The distinction between strain and stocking size effects, however, is not clear because different strains were stocked at different 'typical' stocking weights. The difference between survival of the Seneca and Superior strains (stocked at the same range of weights), and the apparently low survival of Jenny Lake strain (despite large stocking weights), argue that strain plays a role(Fig. 1).

Strain differences in depth distribution would result in different catchabilities and thus distort the results presented here. Elrod and Schneider (1987) showed that different strains of juvenile lake trout occupy different depth ranges. There is also anecdotal evidence that patterns of anglers' catches of Seneca fish differ from those of other strains (C. Schneider, NYDEC, pers. comm.). Elrod (1987) also warns against strain comparisons that are not based on stockings where all factors other than strain are identical.

Mean length at age 3 does not depend on the size at stocking (Fig. 2). Strains stocked at different stocking weights attain similar sizes at this age, and within strains there are both positive and negative correlations between stocking weight and mean length at age 3. There is a significant difference in length at age 3 between the Clearwater and Superior strains (Anova with Tukey's multiple comparison, $P < 0.05$); the Clearwater fish are larger despite having been stocked smaller. No other significant differences were observed between any other two of the Canadian or American strains.

The effect of stocking location on survival is examined in Fig. 3, showing survival at age 3 of the Killala strain fish (the only Canadian strain with appreciable number of data points). No pattern is evident, suggesting that either all stocking locations are equally suitable, or that the effect is minor and masked by other factors and natural variability. Admittedly, this conclusion is based on only few observations.

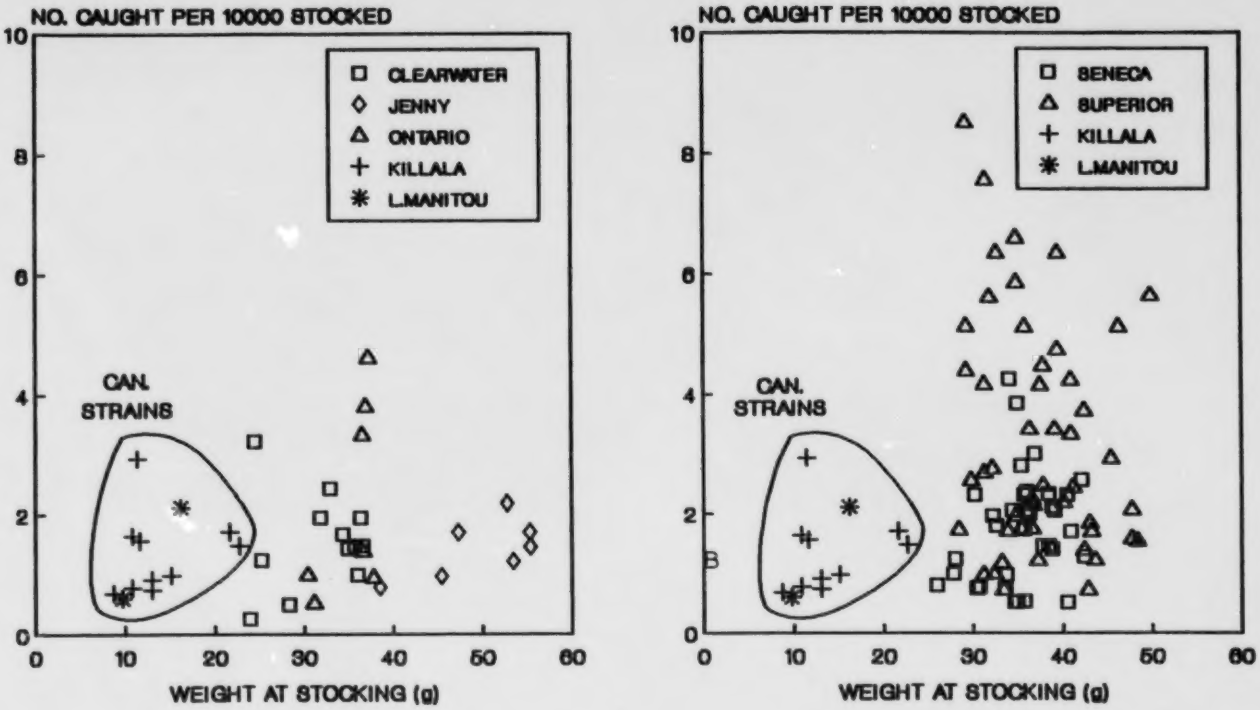

FIG. 1. Survival to age 3 of various strains plotted against mean individual weight at stocking. American strains were split into two plots for clarity, Canadian strains (circled) are shown on both plots for comparison.

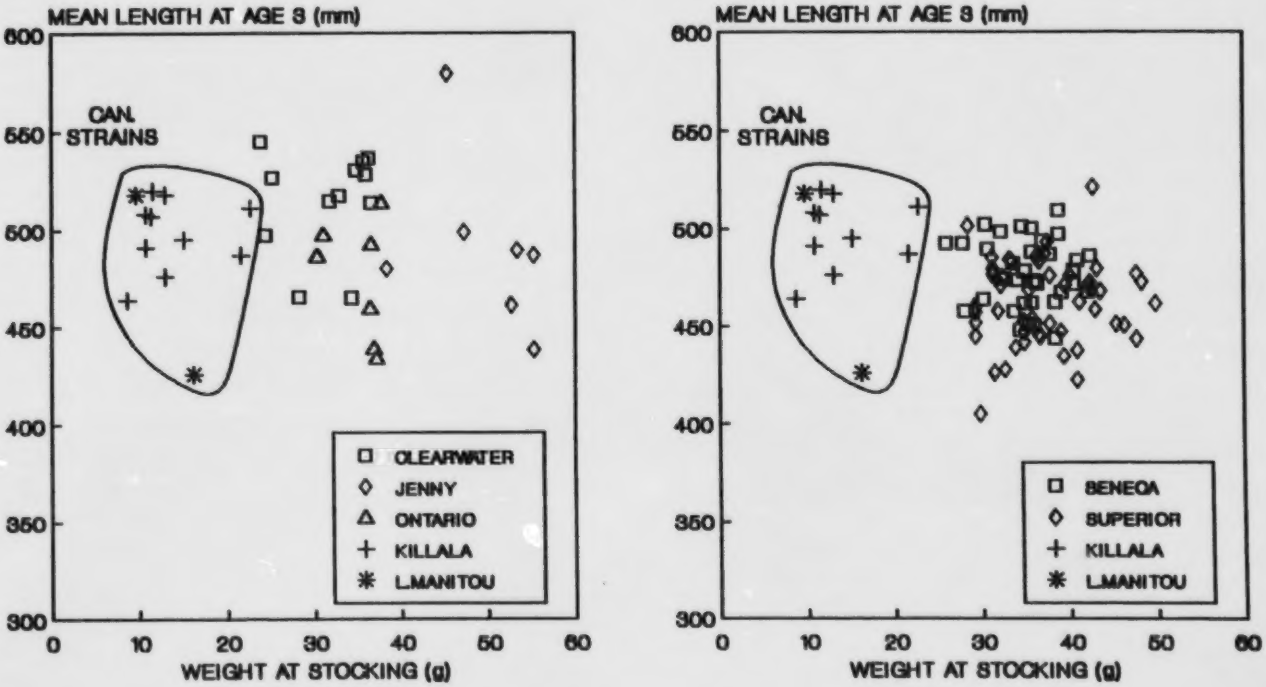

FIG. 2. Mean length at age 3 of various strains plotted against mean individual weight at stocking. American strains were split into two plots for clarity, Canadian strains (circled) are shown on both plots for comparison.

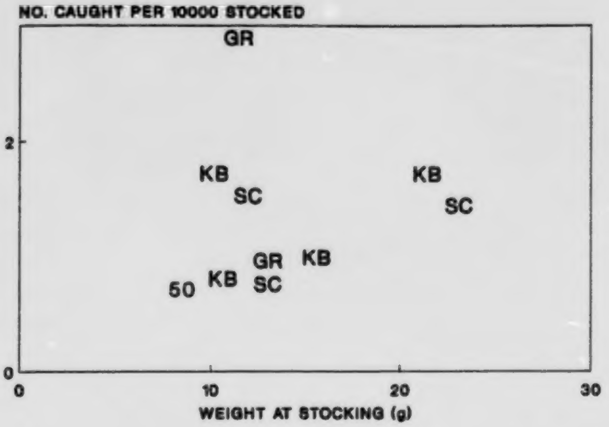

FIG. 3. Survival to age 3 of Killala strain fish with reference to stocking locations. This is a blow-up of the circled region in Fig. 1. Stocking locations: KB = Kingston basin (Main Duck, Charity Shoal and Bath), SC = Scotch Bonnet, 50 = Fifty Mile Point, GR = Grimsby.

Data on older Canadian stocked fish are so limited that no formal analysis or comparisons were made. Cursory examination of survival and growth data did not suggest any obvious differences between Canadian and U.S. fish.

Distribution

Distribution of Canadian stocked lake trout was examined by dividing the lake into six sectors, and for each stocking group comparing the distribution of recaptures to the sector where the fish were stocked (Table 2). A map of the sectors is shown in Fig. 4.

Most fish were recaptured in or near their stocking sector. Some movement did occur, especially among fish stocked in the Kingston basin (Northeast sector), many of which were recaptured in the Canadian waters to the west (North-central sector), and in the U.S. waters to the south (Southeast sector). It is striking though, how few of these fish were captured in the Northwest, Southwest and South-central sectors. Similarly, there were no recaptures of Northwest stocked fish in the Northeast.

Table 2. Numbers of recaptured Canadian fin clipped fish by location of stocking and location of recapture. Explanation of stocking group descriptions: 79-SUP-6 refers to 1979 year-class of Superior strain fish recaptured as 6 year olds; LM = L.Manitou strain, KL = Killala strain, MISC = mixture of strains (Superior and L.Manitou, marked with a common clip combination).

		Recapture Location						
Stocking Group	Exact Stocking Location	NE	NC	NW	SE	SC	SW	Total
FISH STOCKED IN NORTHEAST: (NE)								
81-LM-4	Main Duck	11	1	0	2	0	0	14
81-LM-5	Main Duck	23	1	0	4	0	0	28
83-KL-3	M.Duck + Charity	3	5	2	4	0	0	14
83-KL-3	M.Duck + Charity	4	5	1	1	0	0	11
85-KL-3	M.Duck + Charity + Bath	31	5	0	5	0	0	41
86-KL-3	M.Duck + Charity	18	8	0	2	0	1	29
FISH STOCKED IN NORTH-CENTRAL: (NC)								
84-KL-3	Scotch Bonnet	6	7	2	2	0	0	17
85-KL-3	Scotch Bonnet	2	15	0	2	0	0	19
86-KL-3	Scotch Bonnet	2	8	0	1	0	0	11
FISH STOCKED IN NORTHWEST: (NW)								
83-KL-3	Grimsby	0	0	12	1	0	3	16
84-KL-3	Grimsby	0	0	4	1	2	2	9
85-KL-3	Fifty Mile Point	0	1	6	1	0	0	8
86-LM-3	Fifty Mile Point	0	0	15	0	2	1	18
FISH STOCKED IN NORTHWEST AND NORTH-CENTRAL: (NE & NC)								
79-SUP-6	P.Weller + P.Hope	0	3	2	0	1	0	6
79-SUP-7	P.Weller + P.Hope	1	5	1	1	0	0	8
82-LM-3	Grimsby + P.Hope	0	2	4	0	0	1	7
FISH STOCKED THROUGHOUT LAKE: (NE & NC & NW)								
80-MISC-5	Grimsby to M.Duck	39	4	14	0	2	1	60
80-MISC-6	(4 sites)	30	7	17	1	1	0	56
80-MISC-7		21	2	23	1	2	1	50

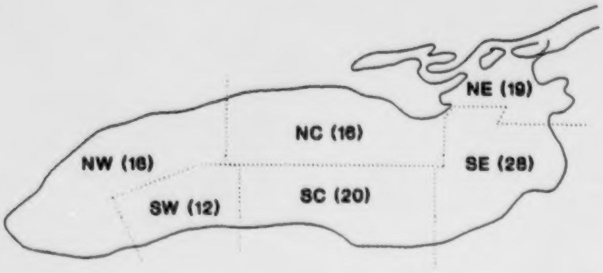

FIG. 4. Sectors used in the analysis of distribution.

Most of the evidence suggesting limited dispersal comes from 3-yr old fish, though the limited data from older fish confirms the same pattern. Lake trout either permanently remain near where they were stocked, or return to their stocking areas in the fall. The former possibility is more likely, since Elrod (1987) found dispersal patterns in July and August that were similar to the ones reported here for September.

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Surveillance Report for Lake Trout Rehabilitation in Lake Ontario, 1990

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Survival of adult lake trout in Lake Ontario continued to improve in 1989. Survival of young adults was better than older fish. Average age of mature females declined, but this was due to a drop in mean age at onset of maturity. Both wounding rate and carcass density were the lowest observed. Mean age and median length of carcasses continued to increase. Relative abundance of mature females was the highest recorded for both Canadian and U.S. waters. Harvest of lake trout remained low on both sides of the border. A total of 135 lake trout fry were collected from Stony Island reef and a single fry was captured from Yorkshire Bar. The peak catch of fry at Stony Island occurred just prior to the arrival of alewives on the reef. Greater than 60% of the Stony Island fry were from Seneca origin. Lake trout eggs were collected in the fall from five separate locations; two sites provided enough eggs to permit parental strain analysis. Condition of lake trout remained unchanged, but most age groups were longer. A greater proportion of age 5 Superior strain females matured and there was no substantial recruitment of naturally produced lake trout.

Introduction

Reconstruction of a naturally reproducing population of lake trout is the focus of a major international rehabilitation effort in Lake Ontario. Coordinated through the Lake Ontario Committee of the Great Lakes Fishery Commission, representatives from many cooperating agencies developed a JOINT PLAN FOR THE REHABILITATION OF LAKE TROUT IN LAKE ONTARIO (Schneider, Kolenosky and Goldthwaite 1983), which identified a goal, an interim objective and several strategies for their achievment. The following report is organized along the same lines as the Joint Plan, with the intention to describe progress toward planned objectives. Assessment and monitoring methods have been described in detail in earlier reports; any readers interested in more information should review the appendices in the 1986 Surveillance Report (Schneider et al. 1987).

Strategy 1: Stocking

Since native stocks of lake trout in Lake Ontario are extinct, the major focus of our rehabilitation effort is the establishment of a new Lake Ontario strain(s). This entails rearing and introducing 2.5 million yearlings of various genetic stocks (1.25 million per nation), assessing strain performance, and emphasizing the use of progeny of lake trout that survived to maturity in Lake Ontario.

Numbers of lake trout stocked in 1989 increased from 1988: 871,100 and 1,124,039 yearling equivalents in U.S. and Canadian waters, respectively (Fig. 1). Five genetic strains were stocked in 1989; in order of abundance they were: Killala, Seneca, Superior, Ontario and Manitou lakes strains (Fig. 1). Generally, stocking within the last several years stabilized in Canadian waters, but U.S. stockings were 25% less than the peak in 1986.

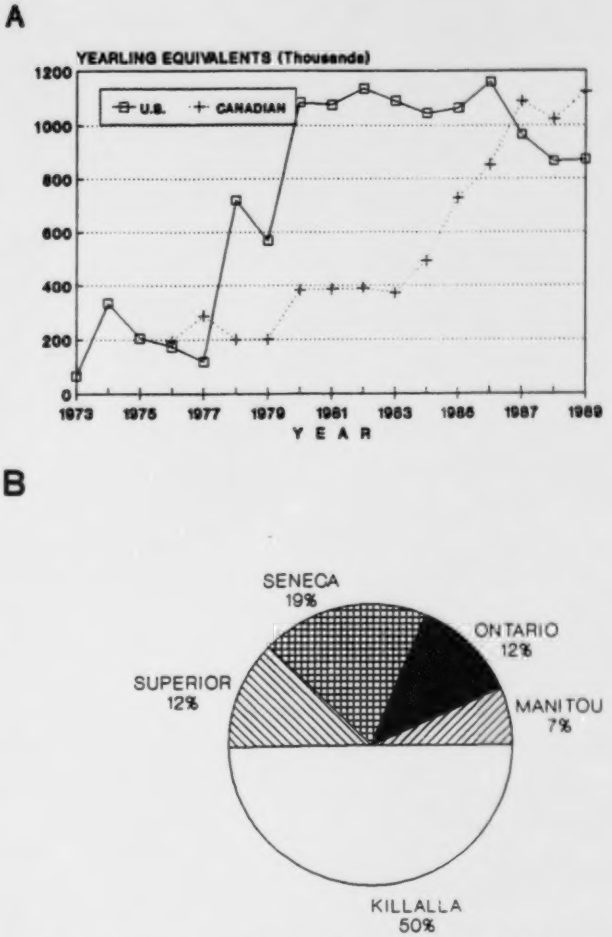

FIG. 1. Lake trout stocking in Canadian and U.S. waters. (A) Total numbers stocked. (B) Breakdown by strain.

Strategy 2: Maximizing recruitment of stocked fish.

The joint plan recommends maximizing recruitment of stocked lake trout by optimizing hatchery rearing practices and stocking techniques. The use of coded wire tags for marking fish has made it possible to initiate studies to evaluate the effects of rearing density, time of planting, and stocking method on post-stocking survival. All U.S. lake trout are reared at a single hatchery. Canadian fish are reared at four different hatcheries, two of which are pond stations. Since 1988, all fish stocked were uniquely marked. Studies of rearing density, stocking method and planting time in U.S. waters were described in previous reports (Schneider et al. 1988), and there is nothing new to add in 1989. In Canadian waters, it is too early to report results of similar studies on fish marked with coded wire tags. Results obtained from Canadian fin clipped fish are reported by Schaner (1990).

Strategy 3: Maintain adult survival between 60-65%

Successful rehabilitation of lake trout in Lake Ontario not only requires stocking sufficient numbers and strains of fish, but also demands that enough planted fish survive to produce a viable spawning stock. The Joint Plan prescribes a survival rate of 60 to 65% per annum. To attain this level the plan further suggests that lake trout deaths from sea lamprey should be minimized and exploitation by the fishery should be limited.

Survival of adults

Today, lake trout adults are surviving better than at any time since the beginning of rehabilitation efforts. After gill net catches were adjusted for numbers stocked, catch curve analysis showed a marked improvement in survival of adult lake trout[1] (Fig. 2). Survival from ages 6 to 10 improved significantly ($P < 0.02$) from 38% in 1988 to 50% in 1989; the 95 per cent confidence limits for the 1989 estimate were from 43% to 60%. Because survival improved throughout the 1980s, old lake trout are becoming more common each year.

The concave shape of the catch curves indicates that survival is poorer for older lake trout. In order to examine survival at different ages, survival was also estimated by comparing gill net relative abundance indices of individual year classes at successive ages. This method provides specific information about survival of individual age groups, but in some years, results can be erroneous, because of variations in catchability (e.g. 1986 and 1987). From 1988 to 1989 survival for all age groups continued to improve, with survival of age 5 to 7 meeting or exceeding Joint Plan objectives: 84% at age 5 to 6, 71% at age 6 to 7, 55% at age 7 to 8 and 43% at age 8 to 9 (Fig. 2). These estimates continue to fit the pattern of survival witnessed over the last several years: more older fish, but with improving survival amongst older lake trout (Fig. 2).

Both anglers and sea lamprey seek the largest lake trout in the population; so we expected that lake trout survival would decrease with age. Although survival of older adults was below the target in the Joint Plan, survival continues to improve. This year, substantial numbers of age 10 fish were captured for the first time.

Average age of adult females

One of the objectives of the rehabilitation program is to re-establish a suitably sized spawning stock that encompasses several year classes. The average age of mature females was selected as an index of age composition. Older average ages indicate populations with more age groups and older fish. The current objective for average age is 7.5 yr.

The average age of adult females taken in gill nets in U.S. waters declined from 6.5 yr in 1988 to 6.3 yr in 1989, reversing a three year trend of increasing average age (Fig. 3). Although female average age declined, the reduction was not the result of poor survival. Rather, it was due to earlier maturity. For Superior strain females, the mean age of onset of maturity dropped from 5.7 yr in 1988 to 5.1 yr in 1989, the youngest age observed (Fig. 3).

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[1] *U.S. data was used for estimating survival because the long-term use of coded wire tags permitted accurate aging of most adults.*

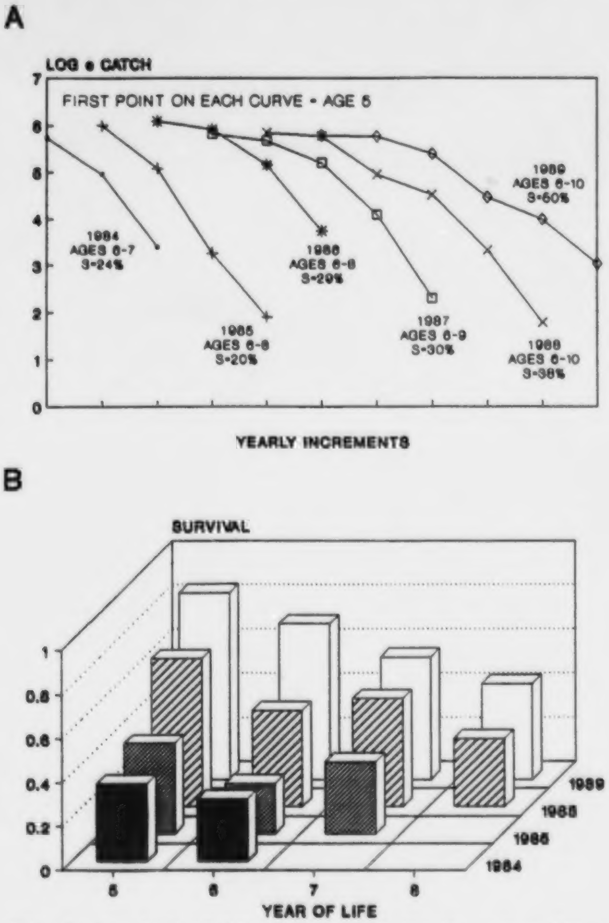

FIG 2. Survival of lake trout. (A) Catch curves from years 1984-89, and survival estimates calculated from slopes in the indicated range of ages. (B) Age-specific survival rates from selected years. Survival at age 5 means survival from age 5 to age 6.

The more important aspect of these changes in average age and age at onset of maturity is not necessarily their decline, but that the difference between the two increased, hereafter referred to spawning index (Fig.3). The difference in average age and onset of maturity was 0.25 yr in 1984 and steadily increased to 1.19 yr in 1989; between 1988 and 1989 it increased 41%. Along with the increases noted in survival, spawning index improvement suggests a continued expansion in numbers of mature females (see following section on prey abundance).

Strategy 3.1: Minimize losses from sea lamprey

Three basic approaches were outlined to minimize sea lamprey predation. First, and foremost, was to minimize sea lamprey recruitment through the use of chemicals, barrier dams and/or other means. Secondly, increasing prey biomass might ultimately lead to reduced mortality of lake trout, since sea lamprey, under conditions of high density of large prey, are thought to function more like parasites than predators. The third tactic outlined in the plan was to stock genotypes of lake trout that were potentially resistant to sea lamprey induced mortality.

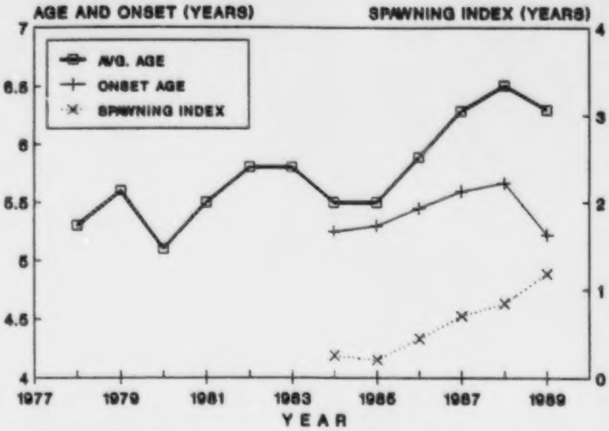

FIG. 3. Maturity statistics for female lake trout. Avg. age is the mean age of mature females. Onset age is calculated by the method of Abrosov (1969). Spawning index is the difference between the two ages.

Monitor sea lamprey impacts

Lake trout carcasses have been collected with bottom trawls in U.S. waters[2] each fall, since 1982. Results from these surveys provide direct and current evidence of sea lamprey induced mortality on lake trout. Total area swept by trawls during these fall surveys ranged from 40 ha in 1982 to 485 ha in 1985 and averaged approximately 390 ha during 1985-88. The number of carcasses recovered ranged from 7 in 1983 to 42 in 1985. In 1989, 15 carcasses were recovered from 299 ha of lake bottom.

Carcass density in the 30-99 m depth strata is the longest and most complete time series (Fig. 4). Density of lake trout killed by sea lamprey decreased, from 0.055 per hectare in 1988 to 0.041 in 1989. This was the lowest density ever observed and indicates the best level of sea lamprey control attained since the program was initiated in Lake Ontario in 1971. Although sea lamprey killed nearly all dead lake trout recovered in fall, in recent years, a smaller proportion were killed by sea lamprey (Fig. 4).

Marking rates have been used throughout the Great Lakes as a measure of lamprey activity. In Lake Ontario, there was a highly significant relation between carcass density and average number of A1 marks on lake trout in September ($P < 0.001$, $r = 0.946$); consequently, A1 marks showed a similar trend. In 1989, the 0.015 marks per fish was the lowest level recorded since lamprey control was begun.

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[2] *In general, lake bottom in U.S. waters is smoother and less obstructed than on the Canadian side, and consequently, this type of effort-intensive sampling is possible only in U.S. waters.*

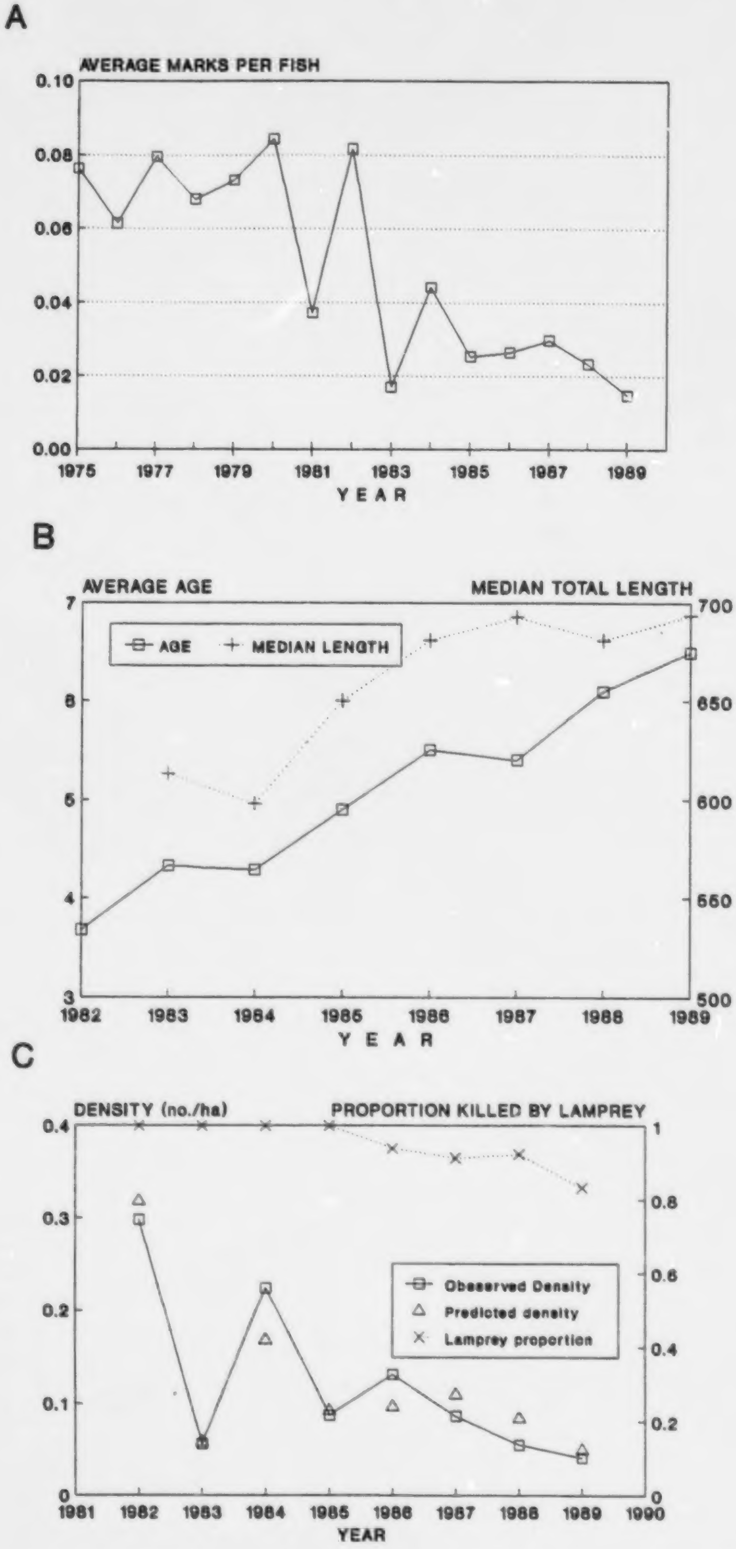

FIG. 4. Lamprey wounding and mortality in the U.S. waters. (A) Marking rates (A1 wounds only). (B) Size and age of lake trout carcasses. (C) Carcass densities and proportions due to lamprey in the 30-99 m depth strata; predicted densities were calculated from the relationship between observed carcass density and A1 wounding rate: density=4.018(wounding)-0.0096, r=0.964.

As carcass density declined from 1982 to 1988, the age and size of carcasses increased (Fig. 4). The increase in average age of carcasses (3.7 in 1982 to 6.5 in 1989) was highly significant ($P < 0.001$). The trend in median total length of carcasses was also significant ($P < 0.01$).

Increase prey biomass

The number of the mature lake trout in Lake Ontario has risen substantially over the last eight years (Fig. 5). Since 1980, relative abundance of mature males and females increased 13 and 14 fold in U.S. waters, respectively; although in recent years it slowed.[3] Since 1984, numbers of mature male and female lake trout increased significantly ($P < 0.05$).

In Canadian waters, relative abundance of mature females was the greatest observed, increasing over two fold since 1988. However, abundance of mature males and immature lake trout (not shown) declined substantially. These lower levels of relative abundance were most likely the result of changes in catchability associated with the distribution of lake trout in Canadian waters in 1989. Also, this is what probably occurred in 1988 when the numbers of adult females declined (Fig. 5).

Strategy 3.2: Limit exploitation

Fishing is the other major, controllable component of lake trout mortality in Lake Ontario. Creel surveys provide an effective and reliable means for quantifying the number of lake trout killed by anglers. This information, in conjunction with carcass survey estimates should permit a reasonable assessment of the corrective actions necessary to improve survival.

Canadian and U.S. creel surveys do not sample all fisheries. There were no Canadian surveys conducted in the Kingston Basin of Lake Ontario in 1989. Although the U.S. creel surveys did not census the Kingston Basin either, the comprehensive survey conducted in 1984 suggested that U.S. harvest estimates for 1985 to 1989 probably represented about 85% of the actual harvest.

Harvest of lake trout by sport anglers was low on both sides of the border (Fig. 6). Anglers creeled only 1,928 lake trout from the Canadian Western Basin (Stewart et al 1990). Another 1,926 lake trout were caught in the Central Basin west of Wellington and by privately moored boats and charterboats; these segments of the fishery were not previously reported. Considerable growth in trout and salmon fishing is occurring in the Kingston Basin, however, there were no recent surveys to document the extent of harvest.

During 1984-87, lake trout harvest in U.S. waters was stable, at about 85,000 fish. In order to reduce angler harvest to 60,000, DEC instituted a slot limit in October 1987 which protected lake trout from 625 mm (25 inches) to 762 mm (30 inches). In 1988, the effect of these restrictions reduced harvest by nearly 60%, to 36,000 fish. Because harvest was lower than the 60,000 fish target, the slot limit was liberalized to 686 mm (27 inches) to 762 mm (30 inches) in July 1989. Although this change took affect in mid-season, harvest, nevertheless, increased 17% to 42,000 fish (Fig. 6).

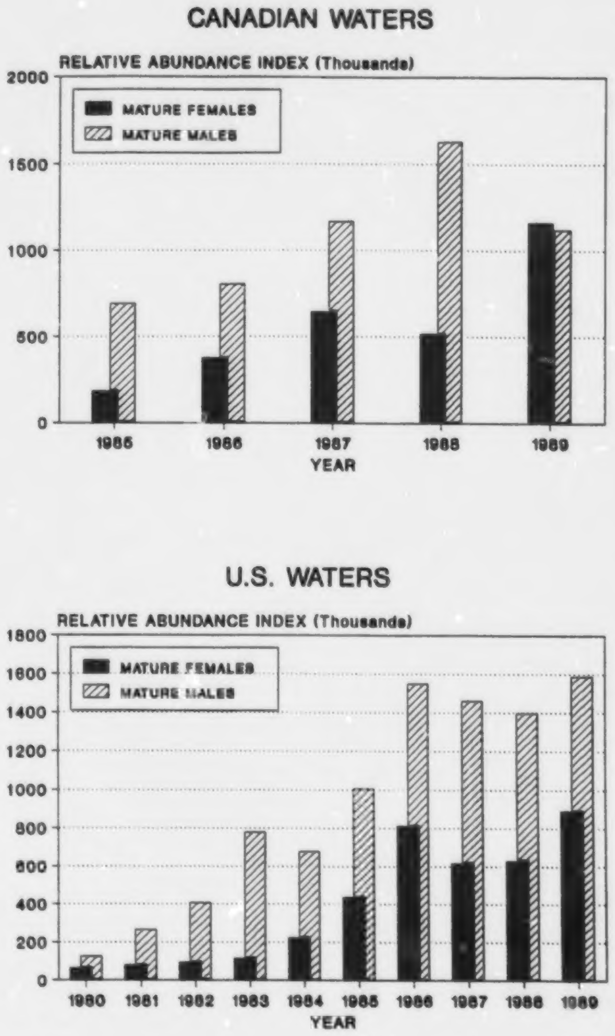

FIG. 5. Relative abundance index in Canadian and U.S. waters. The index is calculated as weighted sum of caught lake trout, with stratum area (hectares) as the weighting factor

Relative exploitation (harvest/relative abundance) by U.S.anglers declined by 83% from 1984 to 1988; contributing to the improvement in adult survival (Fig. 6). Because adult abundance and harvest grew modestly in 1989, relative exploitation increased slightly, but remained near the lowest level observed.

As a result of an OMNR buy-out program, Canadian commercial fishing effort has recently declined. U.S. commercial fisheries are less extensive and are localized near the Eastern Basin. Incidental catches of lake trout in Canadian commercial fisheries added to lake trout mortality, but the recent monitoring indicated these losses were reduced to a minor component. For U.S. waters, magnitude of the in-

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[3] *The high relative abundance for 1986 in Fig. 5 was an aberation because of a shift in catchabillity.*

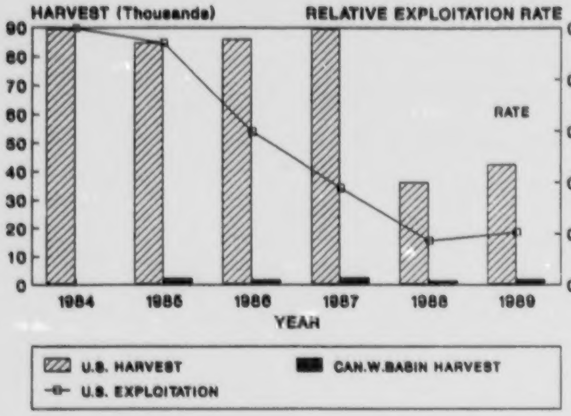

FIG. 6. Lake trout harvest and relative exploitation rate (ratio of harvest to the relative abundance index).

cidental catch is unknown, but it could be appreciable, especially to local spawning stocks.

Overall, lake trout mortality has been managed to the point where survival of mature fish is approaching targets outlined in the Joint Plan. As we proceed into the next decade, the aim of managers should be toward preserving and enhancing the gains made during the 1980s.

Strategy 4: Maximize reproductive potential

In the Joint Plan degradation of the ecosystem was not considered a causal agent in the demise of native lake trout, principally because lake trout were declining prior to the period of most intensive eutrophication and contamination. However, habitat quality is now diminished and may hinder rehabilitation. The suggested approach to maximizing reproductive potential of the new Lake Ontario stock involves: (1) improving water and habitat quality, (2) maximizing use of the least degraded spawning and nursery habitat and (3) determining those conditions on the spawning grounds which may be inhibiting successful reproduction.

Spring fry collections

Sixty emergent fry traps were deployed on a 50 x 10 m area of Stony Island reef, around a central point which was marked during fry trapping in 1988. Fry traps were fished from April 8 to June 1, 1989 and collected 135 fry (Table 1; Fig.7). All fry were transported to Cornell University for parental strain analysis. Fry were analyzed for both allozyme and mtDNA markers. Both data sets were consistent with results obtained in 1986 and 1988; greater than 60% of the fry were of Seneca origin.

Ninety-six emergent fry traps were deployed on Yorkshire Bar at depths ranging from 3 to 9 m. The traps were fished from April 16 to June 5, 1989; only a single emergent fry was caught on May 12.

Table 1. Lake trout fry catch rates from Stony Island, 1989.

Date	No. Traps	No. Fry	Fry Per Trap-Day	% Emergent Fry
April 14	60	4	0.011	0
April 20	60	18	0.050	0
April 27	60	12	0.015	0
May 4	61	74	0.173	27
May 12	60	19	0.040	37
May 18	60	6	0.017	50
May 24	60	2	0.006	100
June 1	60	0	0	-

Alewife abundance vs. lake trout fry capture

Two gangs of monofilament gill nets were placed on Stony Island reef, parallel to and within 30 meters of the location on the reef where lake trout fry were captured. Gill netting occurred on April 14, 20 and 27 and May 4, 12, 18 and 24. On each sampling date, nets were set approximately one hour before sunset and lifted one hour after sunrise. The first alewife was captured on May 4 and catches increased rapidly throughout the month (Fig. 7). At the same time, catches of lake trout fry declined. The peak catch of fry occurred just prior to the arrival of alewife on the reef. The possibility exists, therefore, that alewife may prey upon lake trout fry emerging from Stony Island reef.

Fall egg trapping

One hundred new egg traps were deployed in four lines of 25 traps each on four types of substrate on Stony Island reef. A total of 757 eggs was collected between October 14 and December 6, 1989 (Table 2). As in previous years, eggs were captured primarily adjacent to the eastern edge of the reef where substrate is large cobble-rubble.

Egg traps were also deployed on Charity Shoal (30 traps), Galloo Shoals (60 traps), Yorkshire Shoal (100 traps) and Grimsby Shoal. Many traps were damaged or lost on Galloo

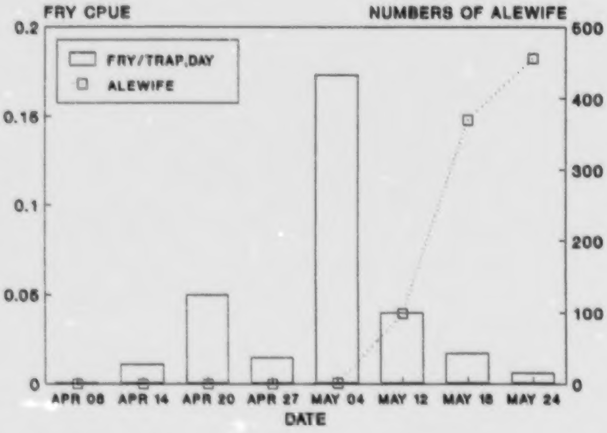

FIG. 7. Lake trout fry collection in spring of 1989 on Stony Island: fry capture rates (no. caught per trap-day), and numbers of alewife caught in overnight gillnet sets.

and Charity Shoals, due to severe storms. However, eggs were captured from all four sites (Table 2).

Two SCUBA dives were made in the fall of 1989 to collect lake trout eggs from reefs located near Yorkshire and Stony Islands in the eastern basin of Lake Ontario. Approximately 5-10% of the eggs observed at both sites were covered with fungus. However, accurate quantification of the dead eggs observed was not attempted and only eggs which appeared viable (i.e. had no fungus) were collected. A total of 142 eggs were collected from the Yorkshire site on November 27, 1989 and 181 eggs were collected from the Stony Island site on December 6, 1989 (Table 2). On the day eggs were collected, 72% of the Yorkshire Island eggs were eyed, while only 7% of those from Stony Island were eyed. All eggs were returned to a hatchery facility located at Cornell University for continued incubation. Eye-up of the Yorkshire eggs was completed on December 13, 1989; 90% of the eggs eventually eyed. Stony Island eggs finished eyeing on January 18, 1990 with a final eye-up of 77%.

Egg incubators

Eggs stripped from 25 females captured in gill nets near Stony Island were used to load 48 experimental incubators, with 50 eggs per incubator. Twenty-four of the incubators were buried in a line, attached to a chain, across the contour of the reef. Twelve incubators were buried in and adjacent to an experimental man-made reef on the southern portion of Stony Island reef. Retrieval of the incubators in the spring will permit analysis of which substrate types support successful egg incubation. Twelve incubators and a loose group of over 1,924 eggs were transported to the Cornell hatchery facility as controls. Survival of the wild eggs caught in traps and stripped eggs is summarized in Table 3. Minimum fertilization rates from 54% to 71% were calculated from the number of eggs which showed signs of development beyond the blastula stage (Table 3).

Natural reproduction

Because all lake trout stocked in Lake Ontario were marked, by either fin-clipping or coded wire tagging, the frequency of occurrence of unmarked lake trout during September surveys is useful in establishing the extent of natural reproduction.

Table 2. Numbers of lake trout eggs collected by divers and in egg traps at various locations in Lake Ontario, 1989.

Site	Collection Method	Total Eggs
Stony	Traps	757
Stony	Divers	181
Yorkshire	Traps	4
Yorkshire	Divers	142
Galloo	Traps	1
Grimsby	Traps	28
Charity	Traps	1

Table 3. Development, eye-up, and minimum fertilization rates of lake trout eggs collected with fry traps and stripped from gill netted fish on Stony Island reef, Lake Ontario.

Egg Source	No. Live Eggs	No. With Embryos Eyed Eggs	No. Eggs	Minimum Fert.
Wild Caught Eggs	834	450	381	54%
Stripped Eggs				
- In Hatchery Jars	1,924	1,359	134	71%
- In Incubators	600	---	361	60%

Production of lake trout fry at Stony Island was documented throughout the 1980s (see previous LOC surveillance reports). Presumably fry were produced at other locations throughout Lake Ontario. Nevertheless, the occurrence of older, unmarked lake trout in gill net collections was minimal and did not improve. In 1989, 1.4% of the lake trout taken lakewide were unmarked (Fig. 8). Aside from 1982, unmarked fish comprised 1.2% to 1.9% of netted lake trout and there has been no measurable improvement ($P > 0.05$). These unmarked lake trout probably represent a background level attributable to coded wire tag rejection and fin regeneration rather than a low level of natural reproduction. Hence, evidence of successful natural reproduction, beyond the fry stage, will occur when frequency of unmarked lake trout improves continually beyond 2%.

Density dependent effects

The Joint Plan recognized that density dependent population responses could confound the attainment of plan objectives. The plan forecast that as the lake trout population expanded, growth rates would decline, age at maturity would increase, fecundity would be reduced, and natural mortality could increase. These kinds of changes were not intended to forebode a population collapse; instead, they are normal

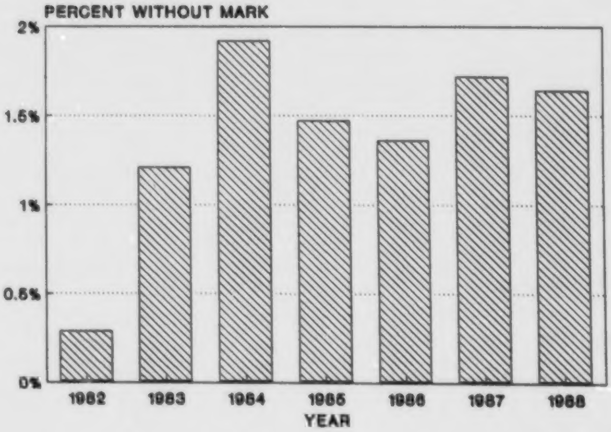

FIG. 8. Frequency of lake trout without coded wire tag or fin clip.

responses that should be expected as the population increases.

Size-at-age

Lake trout condition declined significantly from 1978 to 1986, but remained fairly stable within the last four years (Fig. 9A). Weight-length regressions, calculated from fish taken in September gill net surveys were used to predict the weight of a 600 mm fish and we used this weight as an index of condition. Predicted weights declined significantly ($P < 0.001$) over the 11 year period. The weight reduction was only 15% (about 33 g per yr). Also, weights within the last three years were marginally better than the poorest condition observed in 1986. At the time condition declined, adult abundance increased sharply (Fig. 5). The relation between predicted weight and adult abundance was highly significant ($P < 0.001$, $r = -0.94$).

Prior to 1989, when condition was declining, the length of 2 yr and older Superior strain[4] lake trout remained unchanged ($P > 0.05$). In 1989, however, every age-class, excepting 4 yr olds, was longer than in 1988 (Fig. 9B). Comparisons with t- tests indicated the size increases of ages 1 to 3 was not statistically significant ($P > 0.05$), but age 5 to 9 fish were all significantly longer ($P < 0.05$). The reduction in length of 4 yr old lake trout was significant ($P < 0.05$), but was difficult to explain, given the overall pattern of greater lengths for other ages..

Maturity

From 1984 to 1988, a smaller percentage of 5 yr old Superior strain females were maturing each year ($P < 0.02$, Fig. 8) and the age at onset of maturity was increasing (Fig. 3). Changes in these measures of maturity were both related to increases in adult relative abundance. In 1989, however, these relationships changed markedly. The percentage of 5 yr old females that were mature in 1989, 81.7%, reversed a decline which began in 1984 (Fig. 10). Not only did maturity rebound from the lowest level observed in 1988, but it also surpassed estimates from all other years, some of which were recorded when adult abundance was one-fifth of that in 1989.

The increases in length and age-at-maturity in 1989 was unusual, given that numbers of lake trout adults were at record levels. Furthermore, these observations were not limited solely to lake trout in Lake Ontario. In 1989, condition of angler caught Pacific salmon increased and a world record coho salmon (15 kg, 33.3 lb) was taken from Lake Ontario in 1989, as well as some chinook salmon over 18 kg (40 lb, Schneider et al. 1990). Increased size of salmonines in 1989 may have been related to forage availability, because numbers of adult alewives were near record levels and numbers of yearling alewives were also above average in spring (O'Gorman et al. 1990).

Another possible explanation for the increased sizes of larger lake trout was the effect of the slot limit, i.e., faster growing fish were surviving better. Several factors discount this possibility: 1) the biggest impact of the slot limit was the redirection of effort away from all sizes of lake trout, 2) much of the lake trout harvest (about 25%) was from protected sizes and 3) if the slot limit led to significant increased lake trout lengths-at-age in 1989, why weren't sizes affected in 1988? A review of other Lake Ontario predator data sets would help establish whether conditions for growth were better in 1989.

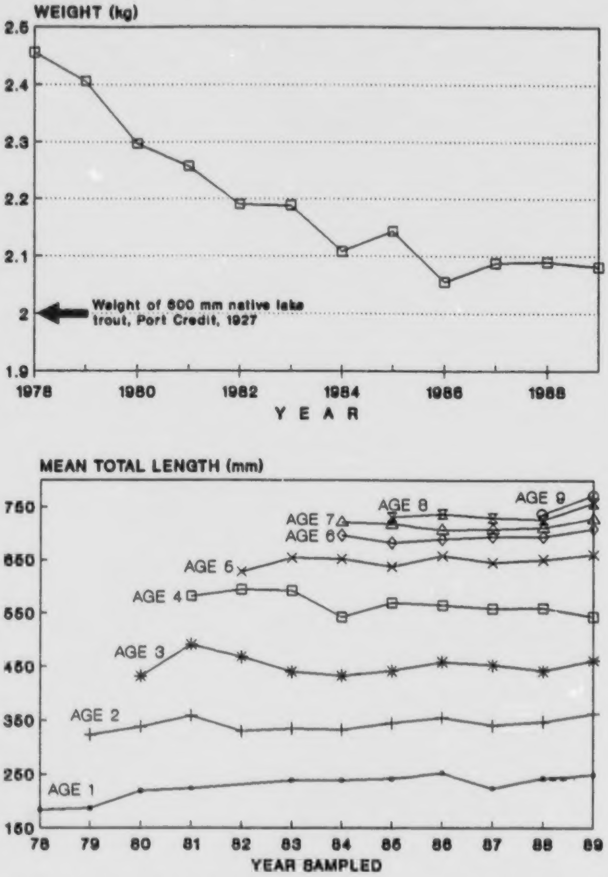

FIG. 9. Growth and condition of lake trout. (A) Length-at-age. (B) Weight of 600 mm lake trout calculated yearly length-weight regressions. Historical data indicate that in 1927, a 600 mm lake trout weighed 2.0 kilograms.

The performance of 4 yr old females was anomalous, as neither growth nor maturity changed (Figs. 9B, 10). This could be a chance error, however, a comparative study of diets during fall gill net surveys may lead to a better understanding of the anomaly.

Recruitment

Throughout the 1980's, when abundance of adult lake trout was increasing, the relative survival of young lake trout in U.S. waters, diminished. Catches of 2- and 3-yr old lake trout, when adjusted for numbers stocked, decreased an average of 16% and 11% per year, respectively, between 1982 and 1989 ($P < 0.05$, Fig. 11). Large catches of 2- and 3-

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[4] *Because strain and size-at-stocking can affect size, Superior strain lake trout were used as a standard for establishing trends in length and maturity.*

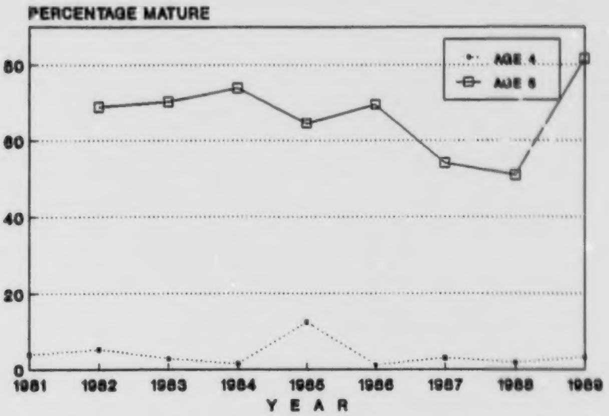

FIG. 10. Proportions of females that are mature at ages 4 and 5.

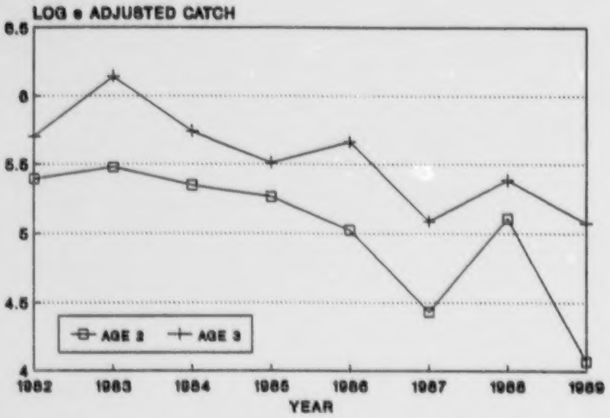

FIG. 11. Recruitment of 2- and 3-yr old fish. Adjusted catched is the catch divided by the number stocked.

yr olds in 1988 suggested a rebound, but 1989 data suggests the higher catches in 1988 were due to sampling error. The suggestion of a strong cohort of 2 yr old lake trout in 1988 was not supported by the catches of 3 yr olds in 1989. Rather, catches of 2- and 3-yr old lake trout appear to move synchronously in response to annual differences in catchability.

Survival of young lake trout was expected to be inversely related to abundance of adults. At the same time catches of 2- and 3-yr old fish declined, numbers of 6-, 7- and 8 yr olds increased 25%, 38% and 46% per annum, respectively ($P<0.05$). Although, no young lake trout have been found in the stomachs of adults captured during fall surveys, predation on stocked lake trout by older adults is not uncommon. For U.S. waters, these declines in relative survival coupled with recent stocking reductions could result in a smaller spawning population in the near future. In Canadian waters, stocking rates have been stable, but as adult densities increase, abundance of young pre-recruits may decline. If the alewife population in Lake Ontario was reduced, due to a major winter die-off, the intensity of predation on recently stocked lake trout, as well as other salmonines, could be severe, on both sides of the border. This, in turn, would result in a great loss of hatchery production and subsequent decline in spawners.

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This is a report on 1989 field activities. Midwater trawling for alewife and smelt, using a frame trawl, provides data suggesting stratification and sample sizes for a future index program. Exploratory fishing for chinook salmon, using large midwater trawl, and midwater and bottom gillnets, suggests that none of these methods is efficient, although midwater trawling gives the highest and most representative catches.

PART I. MIDWATER TRAWLING FOR ALEWIFE AND SMELT

Introduction

Midwater trawling for alewife and smelt in Lake Ontairo was initiated in 1988 (Schaner 1989). The current efforts are aimed at developing an index program to monitor the two species, and to assess the merits of such a program relative to established bottom trawling programs (O'Gorman et al. 1988).

Methods

Fifty-eight midwater tows were completed at night between June 25 and July 28, 1989 in the eastern part of the lake (Fig. 1). The fishing was based on randomly selected stations in 30- and 60 m depths, with additional tows made at 100 m. A temperature profile was taken at each station, determining the layer boundaries between epi- meta- and hypolimnion, and then a constant-depth tow was made in each of the three layers. Additional tows were made at each station to a) replicate one of the layers, b) investigate catches incurred during lowering and raising of the net (zero-time tows), c) investigate catches at the surface, or d) investigate integrated bottom to surface trawling.

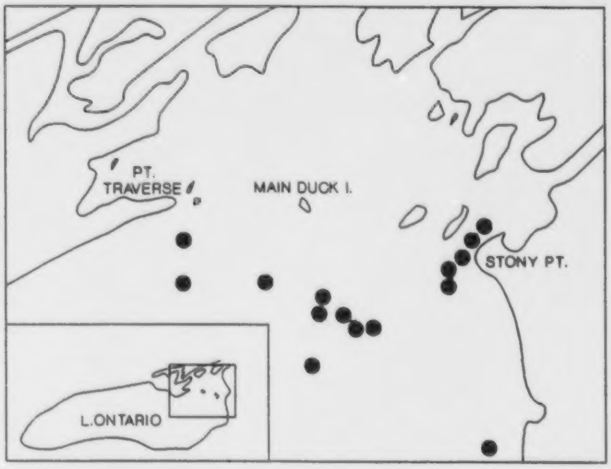

Fig. 1. Map of eastern Lake Ontario showing the trawling locations.

A midwater frame trawl was used. The bag was 11.8 m long, and had a square cross section tapering from 4.2 m sides at the mouth to approximately 0.6 m at the end. The cod end was made of 1/2 inch mesh. The mouth of the bag was attached at top and bottom to 3.17 m horizontal bars maintaining spread. Vertical opening of approximately 2.5 m was insured through floats attached to the upper bar and weights to the lower. The net was towed by a single cable, with bridles running to the four corners of the mouth. All tows were made from the research vessel Seth Green. The engine was kept at 800 rpm, corresponding to over-bottom speed of 1.6-0.97 - 1.39 m/sec (1.9 - 2.7 knots).

All tows were 20 min long, except for the integrated tows which ranged from 19 to 23 min. The depths for constant-depth tows were selected randomly from the range of depths available in each of the three layers. If a replicate tow was made in one of the layers, then a new depth was randomly selected. Tows made to investigate catches during lowering and raising of the net were paired up with one of the constant-depth tows, and the net was lowered to the same depth, immediately followed by retrieval. The surface tows were made at approximately 2 m depth. The integrated tows were all made at the 60 m (bottom depth) sites, and with some variation, the net was raised from 45 to 5 m in 10 m steps made at regular time intervals.

Fish in the catch were separated by species, and then counted and weighed in aggregate. All fish were also length tallied to the nearest centimetre. Catch-per-unit effort (CUE) was expressed as the number of fish caught in 20 min, and the few tows that deviated from this duration were prorated to 20 min. Class frequencies for length frequency histograms were similarly expressed as the number caught in 20 min, and prorated to 20 min where necessary.

Results and Discussion

Alewife catches in all three layers were highest at the 30 m stations, and dropped off markedly with increasing bottom depth (Table 1). At all bottom depths, the catches were highest in the epilimnion, and dropped off deeper in the water column, so that the hypolimnetic CUE at the 30 and 60 m stations were less than a tenth of their corresponding epilimnetic CUE's. Catches at the very surface were lower than the ones made in the epilimnion immediately below. The size composition of the catches varied with the layer (Appendix 1). The largest fish were found in the epilimnion, and the surface tows contained the greatest proportion of young-of-year alewife (20-30 mm).

Smelt catches were also the highest in the 30 m stations, and decreased at greater bottom depths (Table 2). Metalimnion was the layer yielding the highest catches. The upper layers contained the smallest fish, and the surface tows in particular had the highest catches of the young-of-the-year fish (Appendix 2).

Table 1. Mean catches of alewife in 20 min tows. Number of tows and standard error of the mean catch are shown in brackets. Box inside the table indicates the extent of two-way factorial Anova with the following results: significant difference ($p < 0.01$) between layers and between station depths, no interaction; Tukey's multiple comparison: all three layers different from each other ($p < 0.05$).

	Station Depth		
Layer	30 m	60 m*	100 m
Surface		10.2 (5,6.74)	
Epilimnion	49.2 (6,16.1)	28.2 (6,10.6)	3.0 (1,-)
Metalimnion	21.2 (9,7.10)	4.0 (8,1.36)	1.0 (1,-)
Hypolimnion	3.75 (4,2.83)	0.67 (6,0.33)	1.0 (1,-)
Integrated tows		2.05 (4,1.13)	

* 60 m includes a 56 m station

Table 2. Mean catches of smelt in 20 min tows. Number of tows and standard error of the mean catch are shown in brackets. Box inside the table indicates the extent of two-way factorial Anova with the following results: significant difference ($p < 0.01$) between layers and between station depths, no interaction; Tukey's multiple comparison: metalimnion different from epi- and hypolimnion ($p < 0.05$).

	Station Depth		
Layer	30 m	60 m*	100 m
Surface		3.4 (5,1.43)	
Epilimnion	18.8 (6,11.19)	4.83 (6,1.99)	4.0 (1,-)
Metalimnion	77.0 (6,34.2)	16.9 (8,6.9)	1.0 (1,-)
Hypolimnion	11.5 (4,3.77)	1.83 (6,0.54)	0.0 (1,-)
Integrated tows		8.08 (4,2.99)	

* 60 m includes a 56 m station

The patterns in catches of both alewife and smelt are consistent with those observed in 1988 (Schaner 1989), but the differences in size composition from the three layers are the opposite of those seen in 1988.

The efficiency of integrated bottom to surface tows, relative to constant depth tows, is not clear. These tows were stepped at 10 m intervals, and therefore generally contained one epilimnetic, one metalimnetic, and several hypolimnetic towing depths. To evaluate the tows, an 'expected' CUE was calculated for each integrated tow as the weighted average of mean constant-depth CUE's from the three layers, the weighting factor being the proportion of the time that was spent in each of the layers during the integrated tow. Only the data from 60 m stations were used, since all integrated tows were made at this depth. It was found that the expected alewife CUE's ranged between 5.8 and 6.8 fish per 20 min while the actual mean CUE for integrated tows was only 2.1. The opposite was found for smelt: the expected values ranged from 4.6 to 7.3, while the actual mean value was 8.1.

Catches in zero-time tows were compared to corresponding catches in single-depth tows made on the same day at the same station and towing depth (Table 3). Zero-time catches were uniformly low, but in magnitude they were similar to some of the lower catches from single-layer tows.

Few other species were caught in any of the tows. They included lake trout, threespine stickleback, trout-perch, American eel, and slimy sculpin. All were caught in very low numbers.

Table 3. Comparison of constant-depth tows with zero-time tows made to the same depth on the same day.

Target Depth	Number of Fish Caught: In Constant-Depth Tow	Number of Fish Caught: In Zero-Time Tow
Alewife		
23 m (metalimn.)	3	3
18 m (metalimn.)	338	2
21 m (hypolimn.)	2	4
51 m (hypolimn.)	1	6
30 m (hypolimn.)	1	0
Smelt		
23 m (metalimn.)	12	3
18 m (metalimn.)	1	2
21 m (hypolimn.)	3	1
51 m (hypolimn.)	1	2
30 m (hypolimn.)	1	1

Implications for Design of Midwater Trawl Index Program

Midwater trawling with a frame trawl is a suitable method for indexing alewife and smelt. The catches are low, but they are consistent, and the fishing gear itself is convenient to use and inexpensive.

The constant-depth approach appears to be the safest way to proceed at this time. Results with integrated tows are not conclusive. Examining the few integrated tows that were made, it can only be said that the catches come close to expectations based on results from constant-depth tows. Considering, however, that integrated tows encompass a variety of layers and fish densities, they could be more variable, and they would also offer less insight into fish distribution. Integrated tows confined to individual layers are still a possibility, especially if it can be shown that there is no loss in efficiency due to manipulation of the gear during the tow.

In constant depth tows, fish are caught during the lowering and raising of the gear. This would appear to be a problem when sampling a low density stratum that can only be reached by crossing a high density stratum. The easiest solution would be to increase the on-target towing time in order to minimize the relative contribution from the contaminating strata. On the other hand, low density strata will contribute little to the magnitude and variance of any overall index, and therefore refinements in the way that they are sampled may not be worth the effort.

The variance of catches in any of the three strata sampled with constant-depth tows closely follows a generalization made by Green (1979), stating that in many sampling distributions the variance is equal to the squared mean value (Fig. 2). This implies that in each sampling stratum the required number of tows is the same, independent of the mean catch, and dependent only on the desired precision. For example, it would take 64 tows per stratum to achieve an index with 95% confidence limits within 25% of the estimated value (Table 4).

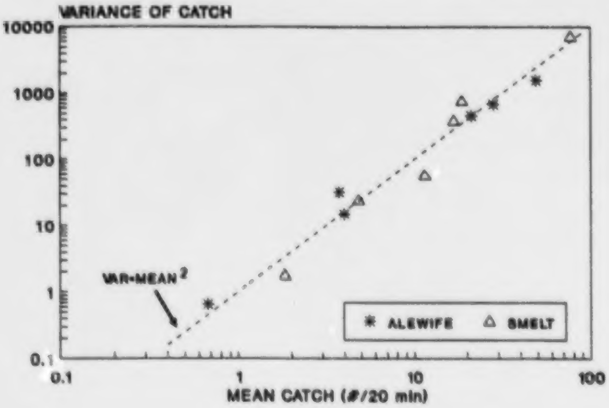

Fig. 2. Relationship between mean and variance of catch in constant-depth tows. The points correspond to those analyzed in Anova (Tables 1 and 2). The line is not fitted, but represents a general relationship found by Green (1979).

Table 4. Number of tows per stratum required to achieve a given width of confidence interval at a given confidence level. Based on the assumption that variance of the catch is equal to the mean catch squared.

Width of confidence interval	Significance level (alpha): 0.2	Significance level (alpha): 0.1	Significance level (alpha): 0.05
50% to 150% of mean	8	13	18
75% to 125% of mean	28	45	64
10% to 110% of mean	166	273	386

The stratification scheme itself cannot yet be determined. Bottom depth and position in the water column (the 'layer') largely account for the differences in density. Other differences probably exist on a large geographical scale. They will become apparent during the first years of the program.

PART II. CHINOOK SALMON PROJECT

Introduction

One of the objectives of the Community Oriented Lake Assessment Program is to provide a measure of the abundance of salmon species in Lake Ontario. In 1989, we carried out a short program of gillnetting and trawling targetted at chinook salmon. This species was picked, so that fishing techniques could be optimized, giving us an indication of highest possible catch rates, and allowing us to evaluate the two techniques.

Capture Methods

The New York State Department of Environmental Conservation (NYDEC) at Cape Vincent Research Station, conducted 18 midwater trawls using the research vessel Seth Green. The trawl used was a rectangular semi-pelagic design with a 9.8 m horizontal opening and a 6.8 m vertical opening. The mesh in the trawl included 4, 3, 2, and 1 inch stretched mesh with a 0.5" mesh cod-end. High-aspect Suberkrub doors with a 1.5 square meter area were used, and the tip of each wing was weighted down with 30 kg of weights to keep the net from emerging. The vessel engine was kept at 1400 - 1475 rpm, corresponding to over-bottom speeds of 1.6 - 1.9 m/sec (3.2 - 3.6 knots) depending on the current.

The Ontario Ministry of Natural Resources (OMNR) at the Lake Ontario Fisheries Unit, conducted three midwater and three bottom gillnet sets. Each net consisted of a gang of seven panels of multifilament gillnet with different mesh sizes (3, 3.5, 4, 4.5, 5, 5.5, and 6 inch stretched mesh). There were 50 yd of each mesh. The nets were set in late afternoon and lifted the next morning. Temperature profiles were taken at both times.

All fishing was conducted south of Main Duck Island during the last week of July and the first week of August. This area was chosen because angler catches in this area suggest that chinook were abundant there during the survey. The depth at which to set the gear was also chosen to optimize catches. The chinook salmon were expected to be in 12- to 14°C, and both the midwater and the bottom sets were made at appropriate depths determined from temperature profiles. In some cases the trawls were conducted above or below the 12C isotherm on an exploratory basis.

Fish Sampling

Alewife, smelt, spottail shiner, threespine stickleback and trout-perch captured in the NYDEC trawls were were weighted and a tally of total lengths was taken. Individual total lengths, weights, sexual maturity and clip information were recorded on large predatory fish.

Fish of all species caught in the LOFU gillnets were tallied by fork length, and weighed. Data for each mesh size of gillnet were recorded separately.

Fish Catches

Eighteen trawls were conducted during six nights of work. Four bottom and three midwater gillnet sets were conducted during three days of work. The catches of fish in the various types of fishing gear are summarized in Table 5. Trawl catches were standardized to 60 minutes in length. Gillnets catches were standardized to catch per 7 panels of 100 m each.

Bottom and midwater gillnets appear to have similar catches of salmonids with the exception of lake trout which were caught in greater numbers in the gillnets set on the bottom. The trawl catches included a greater number of fish species than the gillnets.

During trawling a distinct band of fish was often visible on the depth sounder in the metalimnion. Nine chinook salmon were caught in nine trawls conducted at the same depth as this band. No salmon were caught in seven trawls conducted outside the metalimnion or when there was no distinct band. The chinook were caught in waters which were 15- to 20°C.

Table 5. Mean catch for midwater trawling, bottom and midwater gillnetting during the salmonid exploratory fishing in 1989. Trawling CUE's presented are the mean for the 18 standardized midwater trawls of 60 min each ('.' indicates no fish were caught). Gillnet CUE's presented are the mean catch for three standard midwater gillnets and for three standard bottom gillnets. Catches in the gillnets were standardized to 7 panels (3- to 5 inch stretched mesh) of 100 m each.

Species	Midwater Trawl	Midwater Gillnet	Bottom Gillnet
Alewife	949.6	108.3	36.3
Chinook Salmon	0.7	2.2	1.1
Atlantic Salmon	0.1	.	.
Brown Trout	2.78.0	4.9	
Lake Trout	3.6	12.3	43.9
Lake Whitefish	.	.	2.2
Lake Herring	0.5	.	1.6
Rainbow Smelt	1450.3	17.3	9.8
White Sucker	1.1	.	.
Lake Chub	.	.	1.1
Spottail Shiner	1.3	.	.
Channel Catfish	0.1	.	.
American Eel	1.1	.	.
Threespine Stickleback	3.5	.	.
Trout-perch	3.3	.	.
Rock Bass	0.1	0.7	0.5
Smallmouth Bass	0.3	.	5.4
Walleye	0.3	.	.

The fork length distributions of the salmonid species caught in this program suggest that the midwater trawls tend to catch a wider range of sizes of fish than either the bottom or the midwater gillnets (Appendix3). In particular, the midwater trawls appear to catch more of the smaller individuals of the each salmonid species examined.

Implications for Future Studies:

The number of samples, particularly gillnet samples, taken during this survey is too small to allow any definitive statements about these techniques. Eleven chinook were caught in six nights of midwater trawling (18 tows). Four chinook were caught in three days of gillnetting (7 gillnet sets). Midwater trawling appears to be the more efficient capture method and also it seems to capture a wider range of sizes of fish. Future refinement of these techniques could lead to some increases in the catch per work day. However, neither method seems like a viable technique to capture the hundreds of fish required for a useful index of chinook abundance. Although the sample sizes during this study were small we suggest that future programs explore alternate methods such as monitoring chinook spawning runs.

Acknowledgments

This is the time for one COLA participant to acknowledge the patience of another: Lake Ontario Fisheries Unit thanks the New York State Department of Environmental Conser-

vation for the excellent field work in 1989, and also promisses that there will be a LOFU boat in the water next year, honest.

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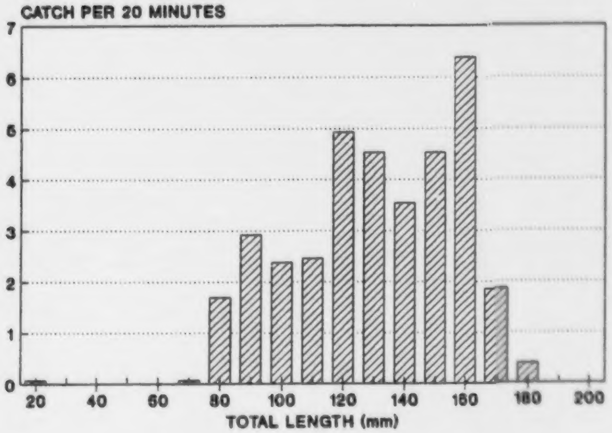
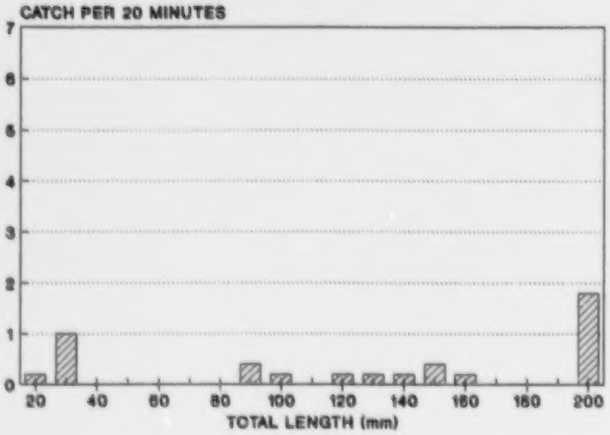
APPENDIX 1

Length frequency distributions of alewife caught in midwater frame trawl, by layer and type of tow. All bottom depths are pooled.

ALEWIFE IN EPILIMNION



ALEWIFE AT SURFACE



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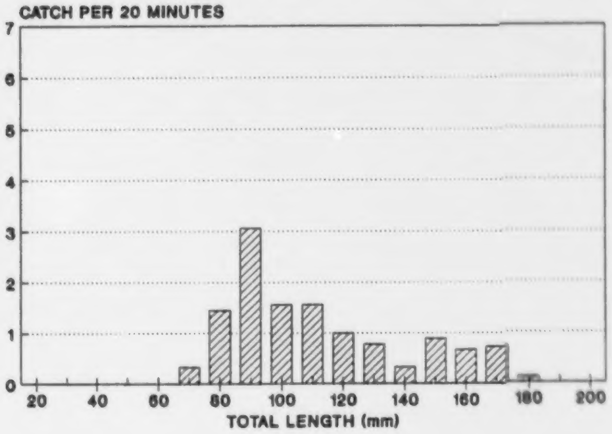
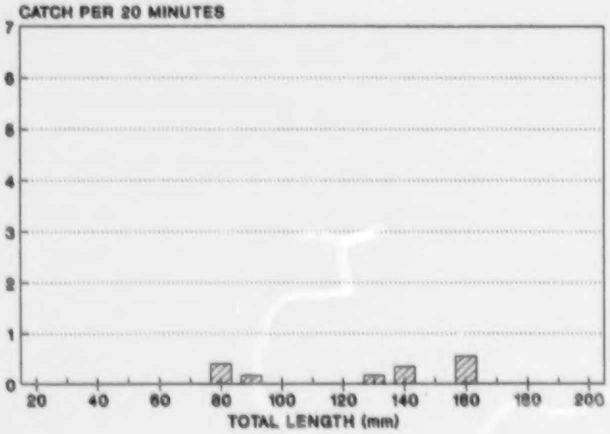
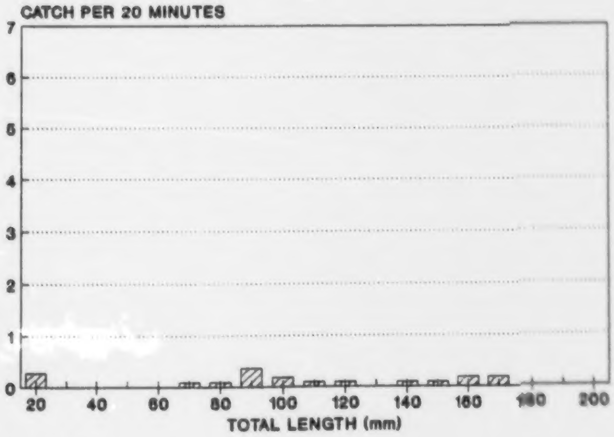


ALEWIFE IN INTEGRATED TOWS



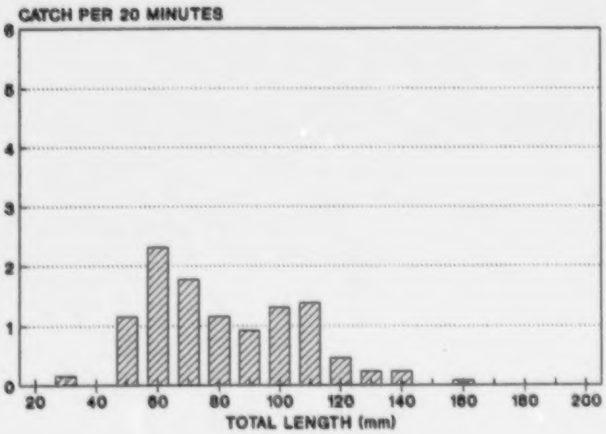
ALEWIFE IN HYPOLIMNION



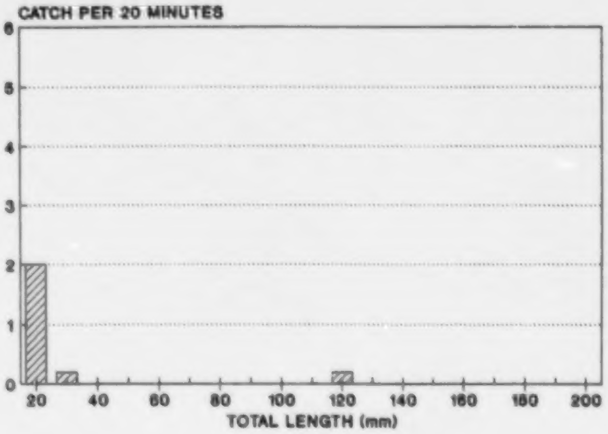
APPENDIX 2

Length frequency distributions of smelt caught in midwater frame trawl, by layer and type of tow. All bottom depths are pooled.

R.SMELT IN EPILIMNION



R.SMELT AT SURFACE



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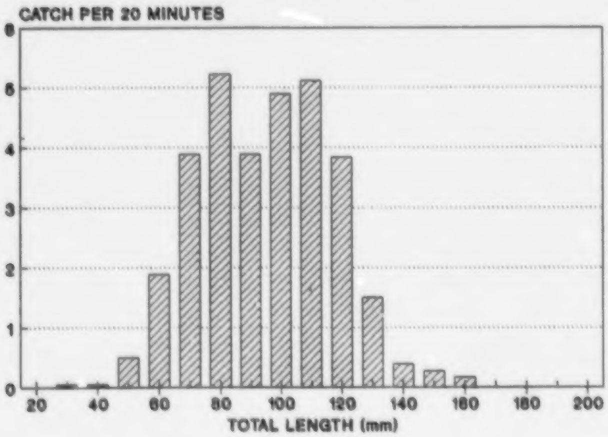

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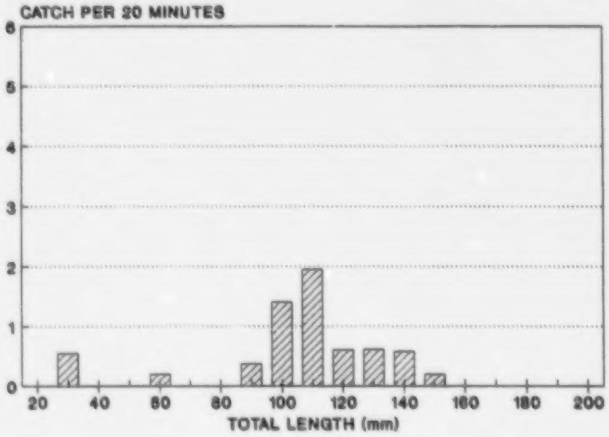
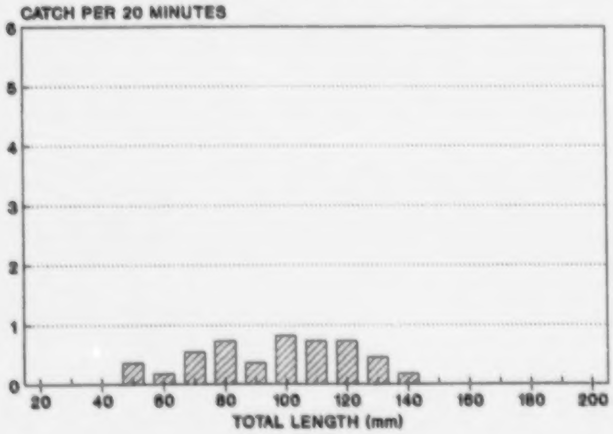


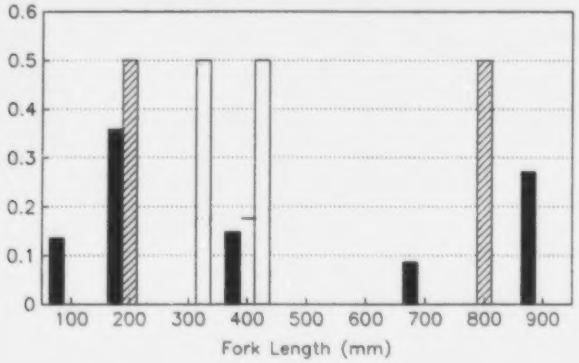
R.SMELT IN HYPOLINION



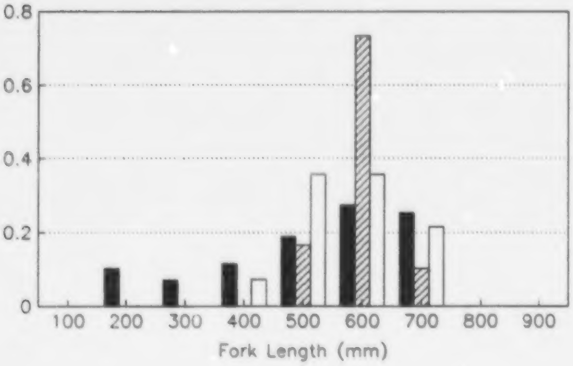
APPENDIX 3

Distribution of catch by fork lengths for (a) chinook salmon (b) brown trout and (c) lake trout during exploratory fishing for chinook using midwater trawls, bottom gillnets, and midwater gillnets. Trawl catches were standardized to 60 minutes. Gillnet catches were standardized to 7 panels (3" to 5" stretched mesh) of 100m each.

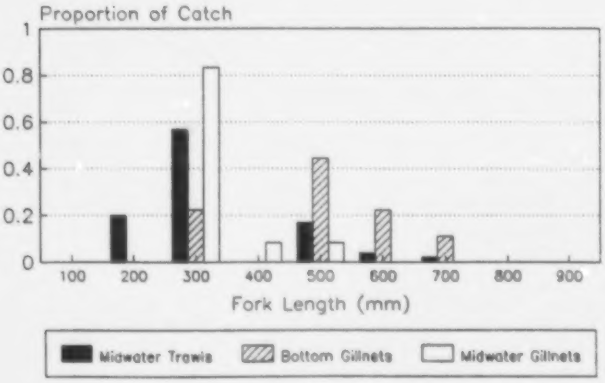
CHINOOK SALMON
Proportions of Chinook Catch by Size
in Each Gear Type.



LAKE TROUT
Proportions of Lake Trout Catch by Size
in Each Gear Type



BROWN TROUT
Proportions of Brown Trout Catch by Size
in Each Gear Type



Credit River Coho Spawning Run, 1989

Celine Plante and James N. Bowlby

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Lake Ontario Fisheries Unit, 1989 Annual Report, LOA 90.1 (Chapter 10)

Coho were sampled in the Credit River during November 20 to November 24, 1989. Of the coho observed in the egg collection, 94.5% were Skagit strain stocked in the Credit River as fall fingerlings in 1987, and as spring yearlings in 1988. Weight of Skagit strain coho showed no trend through time. However, condition has shown a significant decline in all strains, although this decline has appeared to level off for all strains in more recent generations. Yearlings stocked in spring 1988 returned in greater proportion than fingerlings stocked in fall 1987. The rate of return for fall fingerlings was 62% of the rate for spring yearlings. Only one unclipped salmon was caught indicating very low survival of fry stocked in spring 1987. The relationship between spawning size, and size at stocking, showed no significant trend when analyzed by strain or strains combined.

Recommendations

1. Continue monitoring of the coho egg collection.
2. Continue stocking coho as fall fingerlings and spring yearlings.
3. Discontinue stocking of fingerlings into Bronte Creek when habitat becomes rehabilitated.
4. Discontinue fry planting.
5. Test the relationships between coho growth and salmonid and forage fish densities.

Introduction

In 1989, the collection of coho eggs from the Credit River for Ringwood Fish Culture Station, corresponded to the return of the fifth generation of the Skagit River strain. The Skagit River strain is one of three strains that have been alternately stocked on a 3 yr cycle in the Credit River since 1976. Stewart (1989) has already analyzed this data set for the 1977 to 1988 spawning returns. He found that coho stocked as fall fingerlings in 1986, returned in greater proportion than those stocked in spring 1987. Also, he found significant variation of fish size between strains and return sequence, with a general trend to decreasing weight through time.

The objectives of this study for this year were to: 1) summarize biological statistics and lamprey marking occurrence of the coho returning to the Credit River to spawn in 1989; 2) validate the observation of a decrease in coho size with spawning generation; 3) compare the return of fish stocked as fall fingerlings and as spring yearlings; and 4) to test the hypothesis that fish growth is related to the size of fish at stocking.

Methods

Coho were sampled for egg collection in the Credit River during November 20 to November 24, 1989. For more details on egg collection see Stewart (1989). Those coho that were used in further analysis were Skagit strain that were stocked in 1987 and 1988 as fall fingerlings and spring yearlings respectively, and could be discriminated by fin clip (Table 1). The size at stocking was calculated as the mean weight of yearlings only (Fig. 1).

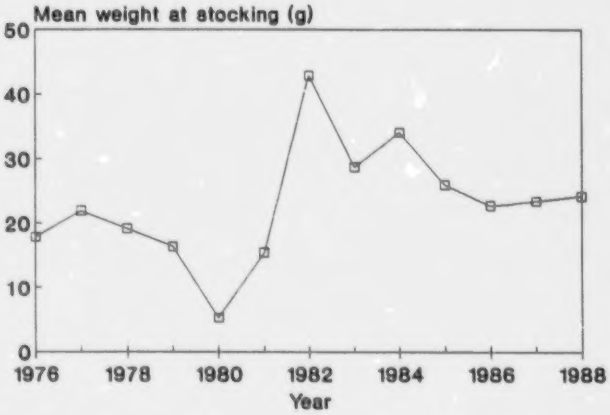

FIG. 1. Mean weight of yearling coho stocked into the Credit River from 1976 to 1988.

Results

Of the coho observed in the egg collection, 94.5% were stocked in the Credit River as fall fingerlings in 1987 and as spring yearlings in 1988 (Table 1). Strays from Bronte Creek or Port Dalhousie accounted for another 3.8%. Females accounted for 52% of the observations and were significantly smaller than males (Table 2). The lamprey marking rate was 0.8% (Table 3) and was consistent with past years observations (Stewart 1989).

Weight of Skagit strain coho showed no trend through time. The third generation was significantly greater in weight and the fourth generation was significantly lower in weight than all other generations (ANOVA, p.001; Table 4). Also, regressions of mean fork length and mean weight versus generation (Fig. 2) were not significant (p0.05). However, condition has shown a significant decline in all strains (ANCOVA, Table 5), although this decline has appeared to level off for all strains in more recent generations.

Table 1. Number of coho observed in 1989 during egg collection in the Credit River, and stocking history. "?" indicates that the information is unknown because the fin clip pattern was not used.

Year of stocking	Stocking location	Age group at stocking	Number Stocked	Fin clip	Number obs.
1987	Credit R.	fry	83,793	None	1
1987	Credit R.	fingerlings	66,337	AD-RV	99
1988	Credit R.	yearlings	51,935	AD	125
1988	Bronte Cr. Port Dalhousie	yearlings	155,164	RV	9
?	?	?	?	AD-LV	2
?	?	?	?	AD-LV-RV	1

Table 2. Size of male and female coho observed during egg collecton in the Credit River in 1989.

Attribute	N	Mean	Max	Min	Standard Deviation
Males					
Total length (mm)	114	744	839	637	38
Fork length (mm)	114	700	790	597	38
Weight (g)	114	4224	6250	2450	747
Females					
Total length (mm)	123	704	766	565	34
Fork length (mm)	123	665	724	525	33
Weight (g)	123	3852	5000	1750	643

Table 3. Lamprey marking on adult coho salmon from the 1989 egg collection from the Credit River.

Type	Stage	Number of marks	mean diameter (mm)
A	I	0	-
	II	0	-
	III	1	-
	IV	1	18
B	I	0	-
	II	0	-
	III	0	-
	IV	0	-

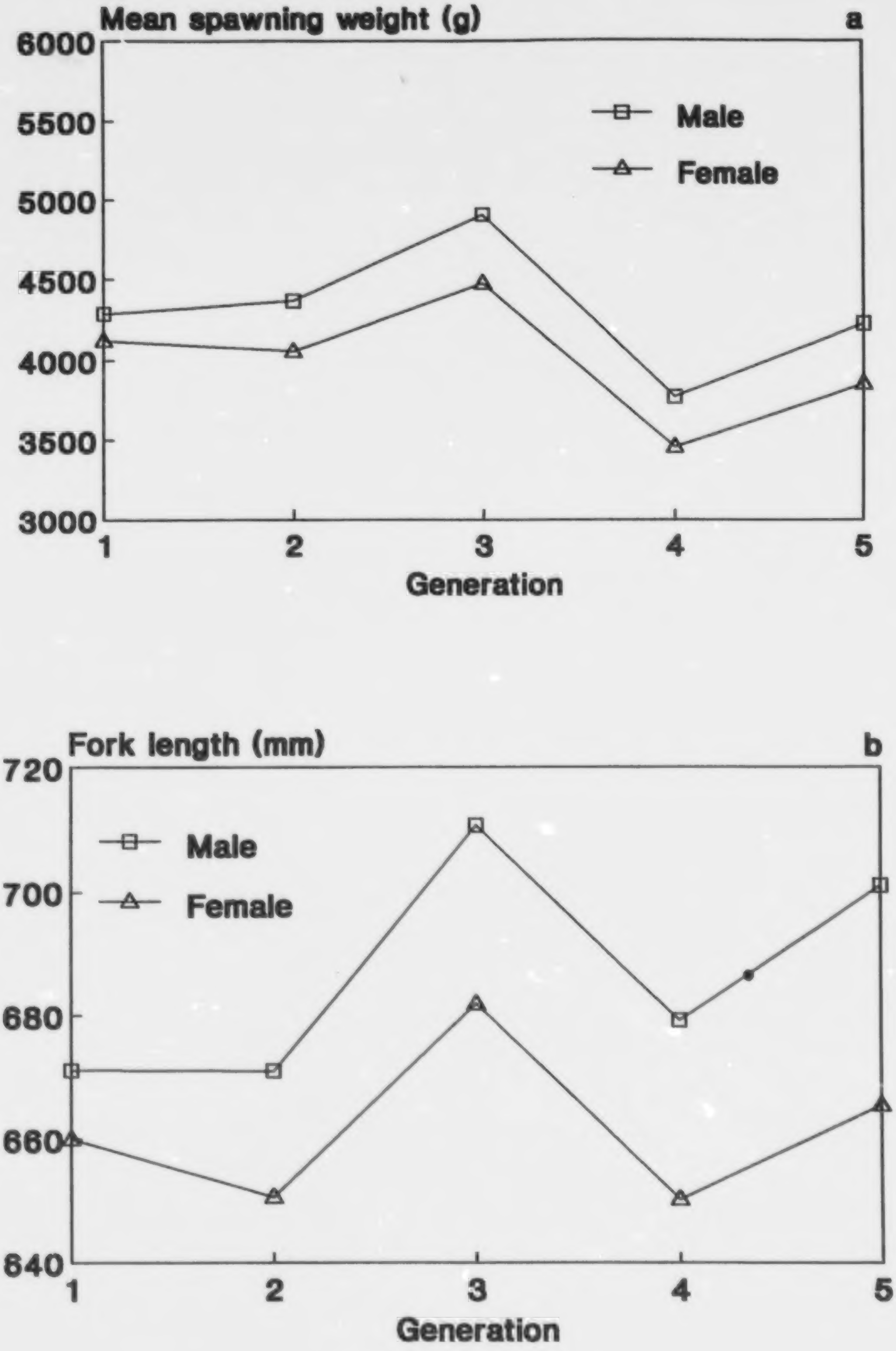

FIG. 2. Size of Skagit strain coho at spawning in the Credit River from 1977 (generation 1) to 1989 (generation 5). a - weight; b - fork length.

Table 4. Mean weight of Skagit coho by generation. Coho were observed during egg collection in the Credit River between 1977 and 1989. Weights with a common underline are not significantly different (p=0.05, Tukey's multiple comparison).

Sex	Generation/Weight (g)				
Males	3	2	1	5	4
	4907	4367	4287	4224	3771
Females	3	1	2	5	4
	4475	4122	4056	3852	3457

Table 5. Least square means of the weight per generation corrected for the fork length (a relative measure of body condition). Coho were observed during egg collection in the Credit River between 1977 and 1989. Weights with a common underline are not significantly different (p=0.05, t-test). The weight of a generation is relative to other generations within a strain; weights are not comparable between strains.

Strain	Sex	Generation/Weight (g)				
Skagit	Male	2	3	1	5	4
		4738	4522	4410	4002	3911
Skagit	Female	2	3	1	5	4
		4229	4160	4148	3794	363
Capilano	Male	1	2	3	4	
		4563	4498	4355	4317	
Capilano	Female	2	4	1		
		4359	4338	4075		
Big Qualicum	Male	1	2	3	4	
		5228	4730	4671	4564	
Big Qualicum	Female	1	2	3	4	
		5123	4708	4663	4452	

Yearlings stocked in spring 1988 returned in greater proportion than fingerlings stocked in fall 1987 (G=12.73, p.01). The rate of return for fall fingerlings was 62% of the rate for spring yearlings. Only one unclipped salmon was caught indicating very low survival of fry stocked in spring 1987. The relationship between spawning size and size at stocking showed no significant trend when analyzed by strain or strains combined (Fig. 3).

Discussion

There is no clear trend in size of Skagit strain coho through time. However, the weight after controlling length (a measure of condition) showed significant declines in all strains. This decline leveled off in a manner consistent with the past increases in stocking of salmonids in Lake Ontario (see Savoie and LeTendre 1988). Accordingly, condition in salmonids in Lake Ontario may be governed by density-dependent factors. Analyses involving forage fish density and salmonid density should follow these analyses here to test this hypothesis.

Coho stocked as spring yearlings returned to the Credit River at a greater rate than coho stocked as fall fingerlings. This result contradicts Stewart (1989). The higher return of fall fingerlings in 1988 could be due to the Bacterial Kidney Desease (BKD) that is known to have infected both fall fingerlings in 1986 and spring yearlings in 1987. Perhaps, fall stocking has a beneficial effect on BKD infected fish. Alternatively, river environments are highly variable and freshets could potentially reduce survival of fall fingerlings one year or spring yearlings in another, depending on the timing of smoltification and stocking. Accordingly, it may be a wise practice to "hedge our bets" by continuing to split the stocking between spring yearings and fall fingerlings.

The return of fall fingerlings and spring yearlings was quite substantial compared with fry. During summer, the water temperature is too warm in the Credit River for survival of salmonid fry (J. Imhof, pers. comm.). However, during fall and winter, the Credit River provides suitable habitat for coho fingerlings because high summer temperatures preclude other salmonids. Similar conditions currently occur in Bronte Creek (L. Halyk, pers. comm.). However, rehabilitation of Bronte Creek summer water temperatures should take place within the next 5 yr, and at that point, natural reproduction of salmonids should fill the salmonid habitat and make Bronte Creek undesirable for planting fingerlings (L. Halyk, pers. comm.). Accordingly, fingerling stocking in Bronte should be discontinued as rehabilitation proceeds.

The size at stocking did not appear to affect the growth of coho. However, the size at stocking has been

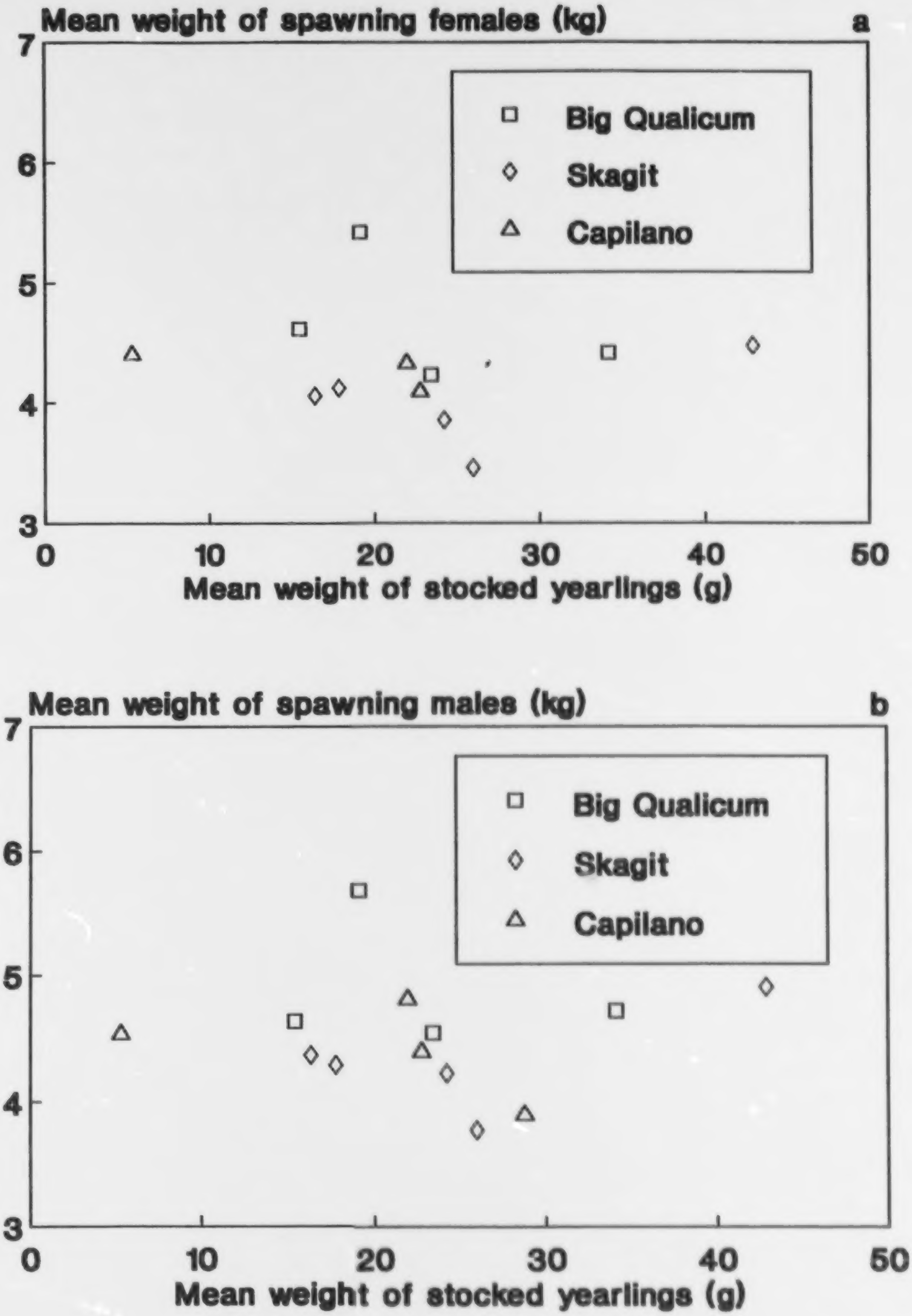

FIG. 3. Relationship between stocking weight and spawning weight of coho by generation in the Credit River from 1977 to 1989 (spawning year). a - male; b - female.

found to influence the survival of lake trout (Gunn et al. 1987), and so maintaining stocking size should still be a goal for hatchery managers.

Acknowledgements

We thank Brian Marchant, Brian Malone, Paul Savoie, and several Ringwood Fish Culture Station technicians for work in the field. Tom Stewart and Carol Ward made comments on a previous draft. Linda Balsillie converted this report to Ventura Format.

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Lake Ontario Stocking And Marking Program for 1989

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Introduction

The Lake Ontario fish stocking and marking program report is prepared annually as a joint effort of the New York State Department of Environmental Conservation (DEC) and Ontario Ministry of Natural Resources (OMNR). The report is prepared to present numbers of fish stocked and identifying marks used on fish stocked into Lake Ontario by both agencies[1]. Tables 1 and 2 provide statistics on numbers of fish stocked in 1988 and 1989, and numbers of fish proposed for 1990 stocking. Tables 3 and 4 provide information on numbers of fish stocked into Lake Ontario from 1968 through 1989 by both agencies. Tables 5 and 6 provide detailed information about the areas of Lake Ontario that were stocked in 1989. In addition, these tables (5 and 6) contain species information including strain, hatchery or origin, size at stocking and marks. Table 7 identifies the deviations from the proposed 1989 stocking and explains the reasons for the changes.

The proposed stocking of trout and salmon by OMNR and DEC during 1990 is presented as numbers of fish by species, expected age of stocking, and proposed stocking sites in Tables 8 and 9.

Comparison of OMNR and DEC Lake Ontario stocking is shown as abundance of each species by percent in Fig. 1 and as actual numbers by age group in Fig. 2. The trend in increased stocking by both agencies is shown in Fig. 3 and the trends by species of fish stocked by both agencies combined is depicted in Fig. 4.

Results

The 1989 Lake Ontario fish stocking by all agencies consisted only of salmon and trout. Private groups in New York raised and stocked walleye from fry provided by DEC from the Oneida Hatchery. The total number of salmon and trout stocked in all Lake Ontario waters was 7,771,200. The stocking of 2,510,500 salmonids in Province of Ontario waters was slightly below the number proposed for 1989 stocking. The New York stocking of 5,260,700 salmon and trout was also below the proposed target. The nearly 72,000 walleye stocked by private groups in New York was the highest since the program began in 1986.

The DEC stocking total dropped nearly 600,000 (10%) fish from 1988 to 1989. Half of the reduction was due to stocking fewer surplus steelhead and rainbow this year. Coho and lake trout declines made up most of the remaining difference. The policy of stocking large fingerling coho each fall, rather than overwintering these fish, means fewer coho yearlings were stocked. This fall there were fewer coho available than last year; therefore, the number appears low but stocking is believed to meet identified needs.

Problems with reduced lake trout yearling stocking in New York were caused by Allegheny National Fish Hatchery trying to catch up with DEC needs which have shifted recently.

The OMNR stocking total dropped by almost 330,000 (12%) fish from 1988 to 1989. The OMNR stocking of coho salmon, Atlantic salmon and lake trout either exceeded proposed numbers or were close. The numbers of chinook salmon, brown trout and rainbow trout were below target. The Lake Ontario stocking by the Province of Ontario is getting closer to meeting each species' objective. Please note corrections to the 1988 OMNR stocking numbers for coho and Atlantic salmon.

The 1989 stocking by American and Canadian agencies was almost 429,000 (5.2%) fish below the agreed upon 8.2 million (+/- 5%) stocking limit for Lake Ontario. That gap will close somewhat in the near future as all agencies approach proposed numbers for stocking.

---

[1] *Most stocked fish are raised in Provincial or State fish hatcheries. Exceptions in 1989 included: lake trout provided by United States Fish and Wildlife Service from the Allegheny National Fish Hatchery; Penobscot strain Atlantic salmon provided by United States Fish Wildlife Service from Tunison Laboratory at Cortland National Fish Hatchery; Grand Lake stream strain landlocked salmon and Clear Lake strain landlocked salmon provided by the Pittsford (Vermont) National Fish Hatchery; and private groups raised walleye fry provided by the DEC and stocked them as fingerlings.*

Terminology

Following are explanations for some of the terms and abbreviations used in the tables and graphs.

Steelhead: a migratory rainbow trout, technically, one which undergoes the parr-smolt transformation and migrates to Lake Ontario from the stream in which it was planted, or hatched in the case of wild fish.

Domestic rainbow trout: a rainbow trout that is not known to exhibit a parr-smolt transformation and, therefore, is planted directly into the lake since it would not be expected to migrate to the lake if planted in a stream.

Atlantic salmon: includes the ocean run strain of fish generally referred to as Atlantic salmon and the lake dwelling strain called landlocked salmon.

Mark	body part removed or tag added for identification
LV:	Left Ventral fin
Ad-LV:	Adipose and Left Ventral fins
RV:	Right Ventral fin
Ad-LP:	Adipose and Left Pectoral fins
LV-RV:	Both Ventral fins
RP:	Right Pectoral fin
LP:	Left Pectoral fin
LV-LM:	Left Ventral fin and Left Maxillary bone
CWT:	Coded Wire Tag (60-42-14; the first two numbers are the agency code; i.e., 60, 23 and 63 are agency codes for FWS, DEC and OMNR respectively, the third through sixth numbers identify individual lots of fish)

Some graphs and tables use fish abbreviations, these are:

Coho:	Coho salmon	Splk:	Splake
Chin:	Chinook salmon	Lake:	Lake trout
Atla:	Atlantic salmon	Brwn:	Brown trout
Rbow:	Rainbow trout	Brok:	Brook trout
Sthd:	Steelhead trout	Wall:	Walleye
Koka:	Kokanee	Salm:	Salmonid

Table 1. Salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1988 and 1989 and proposed for 1990.

Species	Age	Number Stocked 1988	Number Stocked 1989	Number Proposed 1990
Brown Trout	Yearling	387,309	360,092	435,000
	Adult*	342	275	0
	Total	387,651	360,367	435,000
Coho	Yearling	207,099	203,629	160,000
	Fingerling	179,779 ** x	87,024	80,000
	Total	386,878 x	290,653	240,000
Lake Trout	Yearling	1,023,572	1,124,039	1,150,000
Chinook	Fingerling	516,207	541,187	650,000
Rainbow Trout	Yearling	264,140	118,493	175,000
	Fingerling	110,964	0	0
	Total	375,104	118,493	175,000
Atlantic Salmon	Yearling	27,145	60,782	50,000
	Fingerling	21,850 x	15,000	0
	Total	48,995 x	75,782	50,000
	TOTAL	2,738,407 x	2,510,521	2,700,000

* Adult = 34 to 46 month old broodstock fish

** Fingerling included 103,957 fall fingerlings and 75,822 spring fingerlings in 1988

x Corrections to the 1988 stocking report.

Table 2. Salmon and trout stocked (in 100's) in New York waters of Lake Ontario in 1988 and 1989 and proposed for 1990.

Species	Age	Number Stocked 1988 *	Number Stocked 1989 *	Number Proposed 1990
Brown Trout	Yearling	404,300	407,300	500,000
	Fingerling	46,400	38,000	0
	Total	450,700	445,300	500,000
Coho	Yearling	299,800	197,100	320,000
	Fingerling	256,400	213,400	0
	Total	556,200	410,500	320,000
Lake Trout	Yearling	767,500	778,300	1,020,000
	Fingerling	247,100	232,000	180,000
	Total	1,014,600	1,010,300	1,200,000
Chinook	Fingerling	2,848,000	2,752,200	2,700,000
Rainbow Trout				
Washington Steelhead	Yearling	293,700	384,400	330,000
	Fingerling	269,400	75,000	0
	Total	563,100	459,400	330,000
Domestic	Yearling	77,400	93,800	115,000
	Fingerling	150,500	25,000	23,000
	Total	227,900	118,800	138,000
Skamania	Yearling	107,000	0	82,000
Finger Lakes (wild) x Domestic	Yearling	6,800	0	0
Finger Lakes (wild)	Fingerling	38,600	0	0
Atlantic Salmon	Yearling	31,900	49,500	49,000
	Fingerling	5,500	14,700	0
	Total	37,400	64,200	49,000
	TOTAL	5,850,300	5,260,700	5,319,000

* Fingerling stocking in both years includes many surplus fingerlings.

Table 3. Approximate numbers (in 1000's) of salmon and trout planted in Province of Ontario waters of Lake Ontario from 1968 through 1989.

Species	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Coho Y	0	138	148	160	122	272	438	226	166	313	201	156	77	169	112	142	106	191	183	188	207	204
Coho F	0	0	0	0	0	0	0	0	0	0	0	130	172	165	0	76	0	0	90	129	104***	87
Coho f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	76	0
Chin f	0	0	0	89	190	0	225	0	0	0	393	147	18	12	270	125	662	703	598	514	516	541
Lake Y	0	0	0	0	0	0	0	0	194	288	200	201	383	387	391	372	493	729	852	1066	1024	1124
Lake F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	56	0	0
Brwn II +	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0**	0**
Brwn Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	123	122	136	283	256	387	360
Brwn F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0	0	27	14	62	0	0
Brwn f	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Rbow Y	12	10	10	18	107	28	30	7	108	110	114	201	149	81	68	105	110	106	200	306	264	118
Rbow F	0	0	0	0	0	30	94	0	0	0	10	0	0	0	0	0	0	0	0	0	111	0
Rbow f	0	0	0	0	0	0	0	22	0	0	0	0	180	0	0	0	0	0	0	0	0	0
Atla Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	61
Atla F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	22***	15
Splk Y	24	25	0	0	48	39	26	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
Koka f	0	20	45	50	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Koka fry	228	334	1982	678	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTALS	264	527	2185	995	528	369	813	255*	474*	711*	918	835	979	821	889	943	1494	1893	2221	2662	2738***	2511

Legend: II + : Two year old fish
Y: Yearlings, stocked between January and June usually 5" to 9"
F: Fall fingerlings, stocked between September and December usually 3-1/2" to 6"
f: Spring fingerlings, stocked May and June usually 2-1/2" to 3"

* Does not include planting of 15,000 rainbow trout eggs in 1975 or lake trout eggs planted in 1976 (90,000) and 1977 (200,000).

** There were 346 and 275 adult brown trout stocked (spent brood stock) in 1988 and 1989, respectively.

*** Corrections to 1988 stocking report.

Table 4. Approximate numbers (in 1000's) of salmon, trout and walleye planted in New York waters of Lake Ontario from 1968 through 1989.

Species	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Coho Y	25	119	294	122	230	215	147	452	177	40	40	175	0	0	307	396	289	351	194	80	300	197
Coho F	15	0	0	0	0	25	69	361	0	0	40	169	299	0	60	51	454	25	268	0	176	213
Coho f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	0	80	0
Chin f	0	70	140	100	426	691	963	920	593	0	0	222	788	1468	1808	2759	3878	3022	2849	3111	2848	2752
Chin F	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Y	0	0	0	0	0	66	128	0	63	0	505	492	1012	1031	1054	1086	1045	984	1012	818	768	778
Lake F	0	0	0	0	0	0	517	513	274	298	538	193	182	112	205	11	0	202	370	367	247	232
Lake II +	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Brwn Y	0	0	0	0	0	60	81	108	157	162	94	219	257	365	503	479	408	440	442	418	404	407
Brwn F	0	0	0	0	0	0	42	113	153	195	0	0	272	89	153	100	0	0	0	0	46	38
Brwn f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	98	132	0	0	0	0	0	0
Rbow Y	0	0	0	0	0	0	19	0	54	50	41	41	85	76	38	108	93	84	80	91	77	94
Rbow F	0	0	0	0	0	0	10	99	106	67	125	167	411	147	96	105	105	105	23	40	150	25
Rbow f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	0	549	0	0	0	0
Sthd Y	0	0	0	0	0	0	50	0	29	24	147	117	263	260	114	112	293	334	407	443	407	384
Sthd F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	10	55	129	308	75
Brok F	0	0	0	0	0	0	0	0	0	0	0	0	326	106	0	0	0	0	0	0	0	0
Atla Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	25	55	55	58	32	50
Atla F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	7	6	15
Wall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	3	63	72
TOTALS:																						
SALM	40	189	434	222	656	1066	2026	2566	1607	823	1530	1795	3895	3656	4441	5528	6590	6174	5840	5562	5849	5260
WALL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	3	63	72
GRAND	40	189	434	222	656	1066	2026	2566	1607	823	1530	1795	3895	3656	4441	5528	6590	6174	5860	5565	5912	5332

Legend: II + : Two year old fish
Y: Yearlings, stocked between January and June usually 5" to 9"
F: Fall fingerlings, stocked between September and December usually 3-1/2" to 6"
f: Spring fingerlings, stocked May and June usually 2-1/2" to 3"

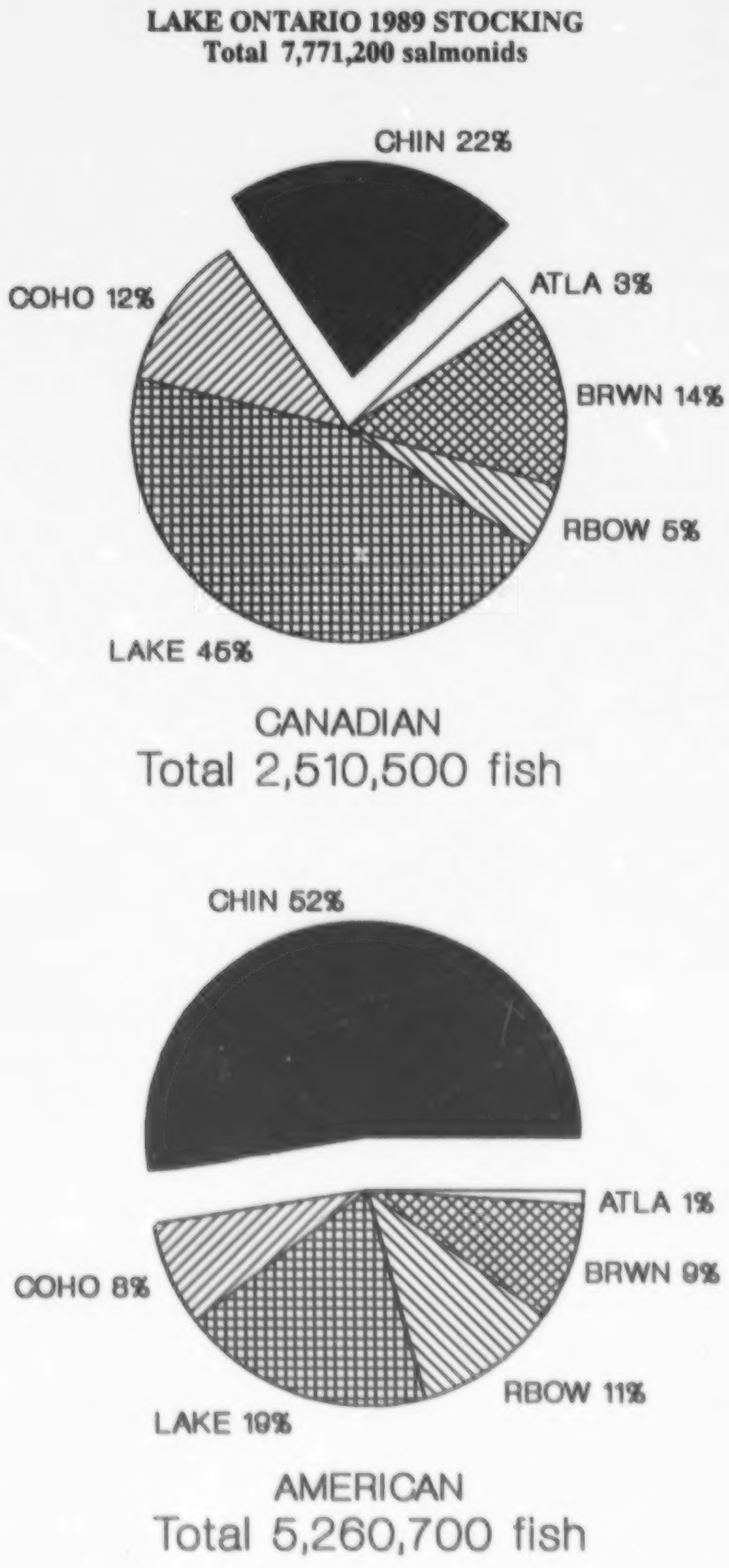
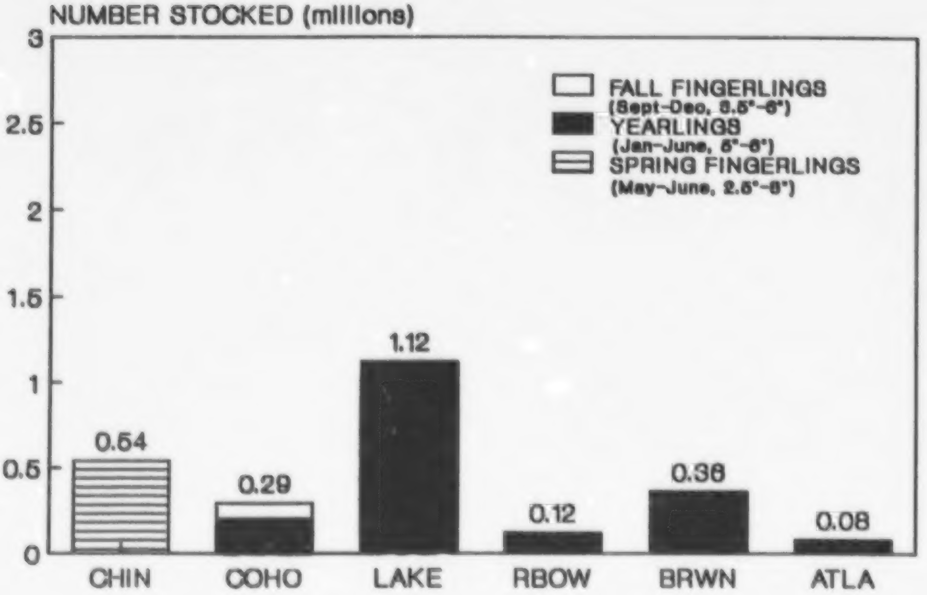


FIG. 1. Lake Ontario salmonid species mix stocked by OMNR and NYDEC in 1989.

CANADIAN
(Total 2,510,500 fish)



AMERICAN
(Total 5,260,700 fish)

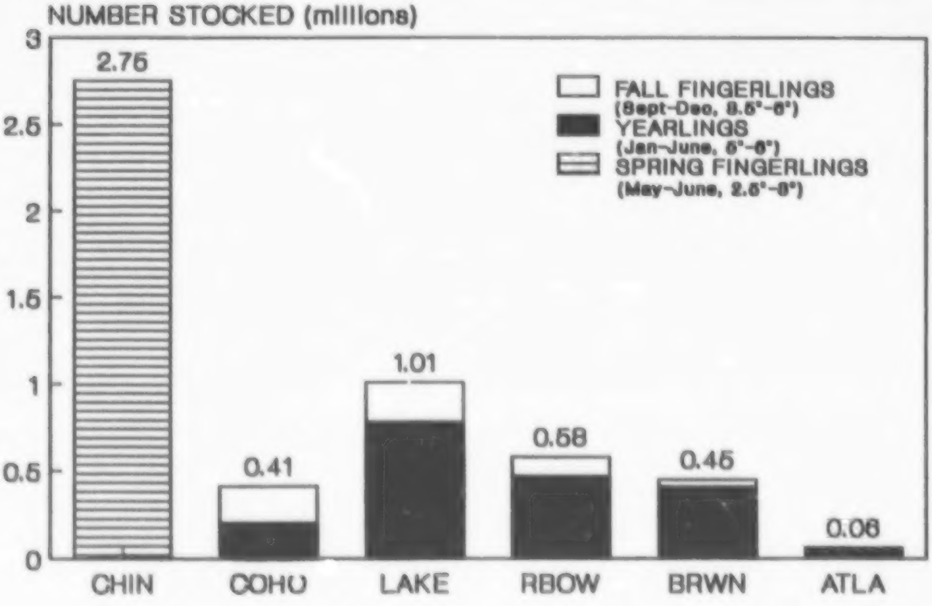


FIG. 2. Lake Ontario salmonid species mix stocked by OMNR and NYDEC in 1989 presented by age group.

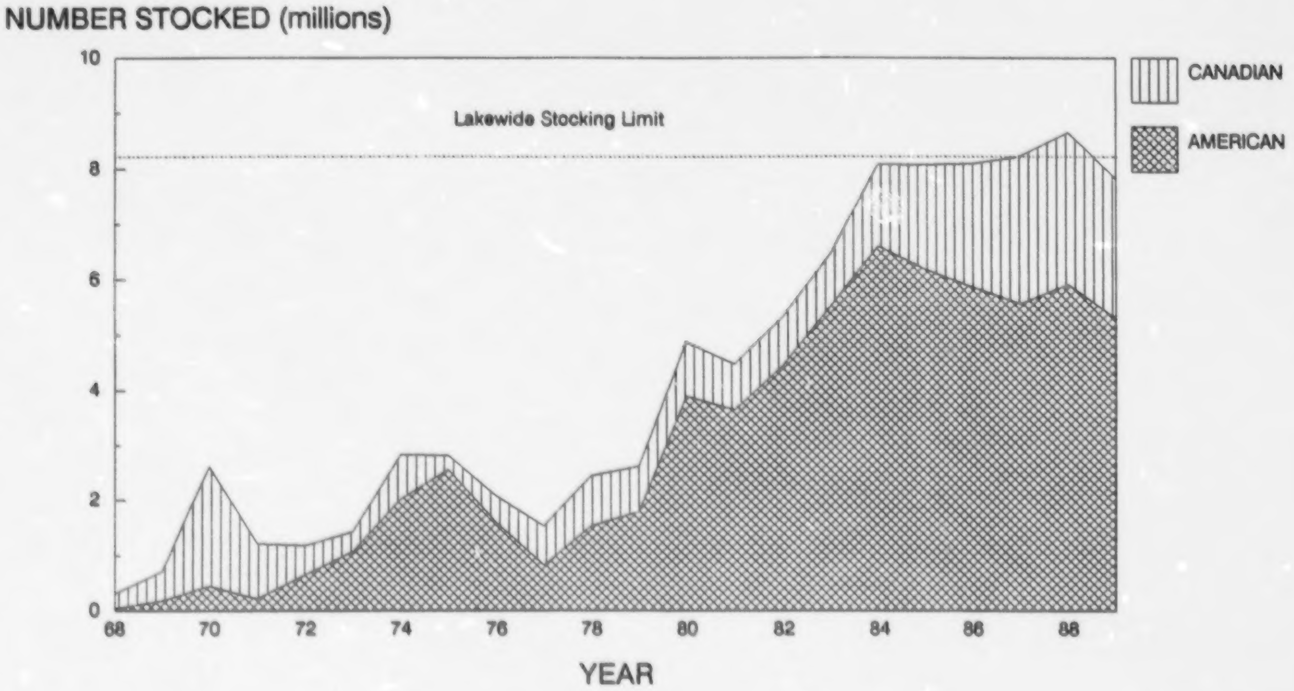


FIG. 3. Lake Ontario stocking trends (all species combined) from Canadian and American sources. Includes yearlings, all fingerlings, some fry and II+ fish. Also includes American stocked walleye beginning in 1986.

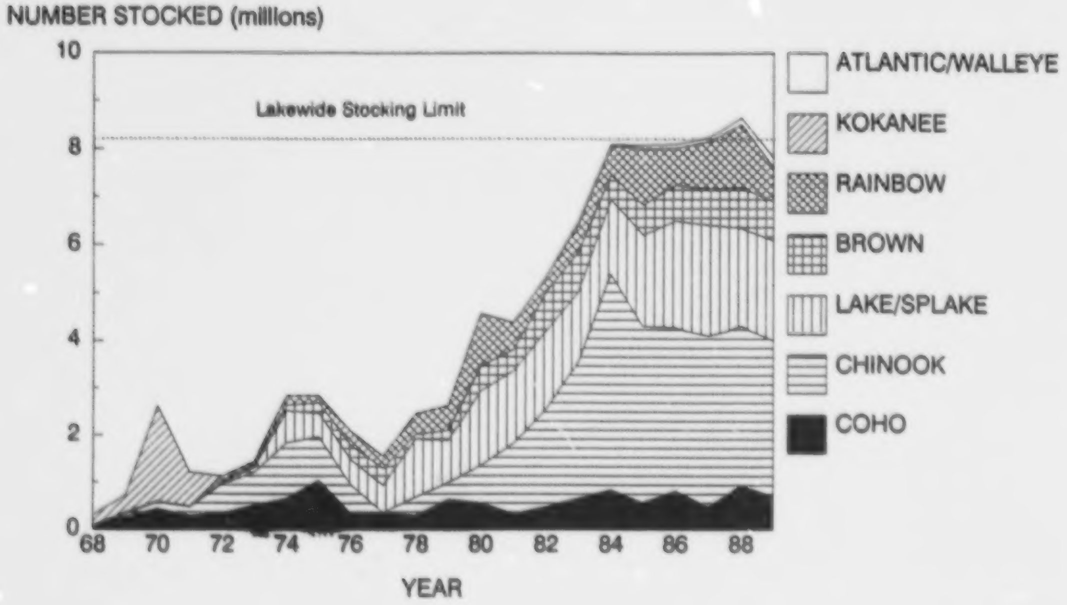


FIG. 4. Lake Ontario stocking trends, by species, for combined Canadian and American plantings. Includes all yearlings, all fingerlings, some fry and II+ fish. Canadian splake (1968-1976) are included with lake trout. U.S. also stocked 326,000 and 106,000 brook trout in 1980 and 1981.

Table 5 Detailed information on salmon and trout stocked in Province of Ontario waters of Lake Ontario in 1989.

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Atlantic Salmon	Credit River	Normandale	Landlocked Grand Lake Str. Maine, U.S.A.	06	81	RV	15,000
		Normandale	Landlocked Grand Lake Str. Maine, U.S.A.	12-13	7	None	28,500
		Normandale	Anadromous LeHave, N.S.	15-16	6	RV	18,550
				CREDIT RIVER TOTAL			62,050
	Wilmot Creek	Normandale	Landlocked Grand Lake Str. Maine, U.S.A.	12	8	AdRV	7,879
		Normandale	Anadromous LeHave, N.S.	15	6	Ad	5,853
				WILMOT CREEK TOTAL			13,732
				TOTAL FINGERLING ATLANTIC			15,000
				TOTAL YEARLING ATLANTIC			60,782
				TOTAL ATLANTIC SALMON			75,782

Table 5. (cont'd)

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Chinook Salmon	Bowmanville Creek	Ringwood	Lake Ontario	06	116	None	21,988
	Bronte Creek	Ringwood	Lake Ontario	06	99	None	64,161
	Cobourg Harbour	Ringwood	Lake Ontario	06	111	None	24,738
	Credit River	Ringwood	Lake Ontario	06	115	None	74,670
		Ringwood	Lake Ontario	06	93	RV	100,136
				CREDIT RIVER TOTAL			174,806
	Hamilton Harbour	Ringwood	Lake Ontario	06	115	None	65,069
	Oshawa Creek	Ringwood	Lake Ontario	06	116	None	21,989
	Port Dalhousie	Ringwood	Lake Ontario	06	96	None	128,042
	Wellington Harbour	Ringwood	Lake Ontario	06	121	None	40,394
				TOTAL FINGERLING CHINOOK			541,187
Coho Salmon	Bronte Creek	Ringwood	Lake Ontario	08	44	AdRV	13,756
				14	23	RV	51,585
				BRONTE CREEK TOTAL			65,341
	Credit River	Ringwood	Lake Ontario	08	34	AdRV	50,596
				14	21	RP	100,631
				CREDIT RIVER TOTAL			151,227
	Port Dalhousie	Ringwood	Lake Ontario	08	33	AdRV	22,672
				13-14	22	RV	51,413
				PORT DALHOUSIE TOTAL			74,085
				TOTAL FALL FINGERLING COHO			87,024
				TOTAL YEARLING COHO			203,629
				TOTAL COHO SALMON			290,653
Rainbow Trout	Bronte Creek	Deer Lake	Ganaraska/ Normandale	13	34	Ad	35,036
	Credit River	Deer Lake	Ganaraska/ Normandale	13	34	Ad	40,601
	Duffin Creek	Deer Lake	Ganaraska/ Normandale	13	33	Ad	30,450
	Rouge River	Deer Lake	Ganaraska/ Normandale	13	31	Ad	12,406
				TOTAL YEARLING RAINBOW TROUT			118,493
Brown Trout	Ashbridges Bay	Harwood	Ganaraska/ Codrington	15	13	Ad	3,194
				17	8	Ad	16,000
				18	7	Ad	5,097
				ASHBRIDGES BAY TOTAL			24,291

Table 5. (cont'd)

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Brown Trout	Bluffer's Park	Harwood	Ganaraska/ Codrington	15	14	Ad	20,250
	Bronte Creek	Harwood	Ganaraska/ Codrington	18	7	Ad	12,498
	Collins Bay	Codrington	Ganaraska/ Codrington	15	15	Ad	18,662
	Duffin Creek	Harwood	Ganaraska/ Codrington	15	13	Ad	20,250
	Fifty Point	Harwood	Ganaraska/ Codrington	17	7	Ad	4,328
		Harwood	Ganaraska/ Codrington	18	7	Ad	8,171
				FIFTY POINT TOTAL			12,499
	Ganaraska River	Codrington	Ganaraska/ Codrington	15	16	Ad	25,000
	Hamilton Harbour	Harwood	Ganaraska/ Codrington	18	7	Ad	12,494
	Humber River	Harwood	Ganaraska/ Codrington	15	14	Ad	20,250
	Millhaven	Codrington	Ganaraska/ Codrington	14	16	Ad	75,728
		Codrington	Ganaraska/ Codrington	34	0.6	RP	166
		Codrington	Ganaraska/ Codrington	46	0.25	RV	109
				MILLHAVEN TOTAL			76,003
	Oshawa Creek	Codrington	Ganaraska/ Codrington	15	15	Ad	25,000
		Harwood	Ganaraska/ Codrington	18	6	Ad	12,621
				OSHAWA CREEK TOTAL			37,621
	Port Dalhousie	Harwood	Ganaraska/ Codrington	15	13	Ad	25,000
	Rouge River	Harwood	Ganaraska/ Codrington	15	14	Ad	24,300
	Burlington	Harwood	Ganaraska/ Codrington	18	7	Ad	12,817
	Twenty Mile Creek (Jordan Harbour)	Harwood	Ganaraska/ Codrington	15	13	Ad	8,697
				17	7	Ad	9,735
				TWENTY MILE CREEK TOTAL			18,432
				TOTAL YEARLING BROWN TROUT			360,092
				TOTAL ADULT BROWN TROUT			275
				TOTAL BROWN TROUT			360,367

Table 5. (cont'd)

Species	Location	Hatchery Reared	Strain or Egg Source	Age Months	# Fish/ Pound	Mark	Number Stocked
Lake Trout	Fifty Point	Deer Lake	Killala Lake/ Dorion	16	32	AdLP	120,925
	Cobourg Harbour	Harwood	Killala Lake/ Dorion	14	14	63-38-18 to-22	107,233
		Deer Lake	Killala Lake/ Dorion	16	37	63-37-37 63-38-13 to-17	112,223
				COBOURG HARBOUR TOTAL			219,456
	Main Duck Island	White Lake	Killala Lake/ Dorion	15	24	63-37-51 to-63	232,984
		Harwood	Killala Lake/ Dorion	17-18	8	63-38-23 to-28	126,292
		Harwood	Lake Manitou	17	10	63-38-32 to-37	130,516
				MAIN DUCK ISLAND TOTAL			489,792
	Port Hope	White Lake	Killala Lake/ Dorion	15	32	63-38-7 to-12	108,152
Lake Trout	Scotch Bonnet	White Lake	Killala Lake/ Dorion	14-15	20	63-38-1 to-6	122,096
		Harwood	Killala Lake/ Dorion	17	9	63-38-29 to-31	42,286
				18	8	63-38-29 to-31	21,332
				SCOTCH BONNET TOTAL			185,714
				TOTAL YEARLING LAKE TROUT			1,124,039

Table 6: Detailed information on salmon, trout and walleye stocked in New York Lake Ontario waters in 1989.

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Atlantic Salmon Yearlings										
Lake Ont.	Shore Oaks	622	5/9	1988	Pittsford	*	16	28.4	None	22,020
Lake Ont.	Hamlin Beach	713	6/2	1988	Pittsford	*	17	17.1	None	22,000
Little Sandy Ck.	Norton Road	0.55	4/28	1988	Tunison	Penobscot	16	22.7	Ad-LV	3,900
Little Sandy Ck.	Norton Road	0.55	4/28	1988	Tunison	Penobscot	16	11.4	Ad-LV	1,300
Oswego River	Oswego Harbour	0.66	9/25	1988	Tunison	Penobscot	21	20.2	None	290
					TOTAL ATLANTIC SALMON YEARLINGS					49,510
Atlantic Salmon Fingerlings										
Oswego River	Oswego Harbour	0.66	9/25	1989	Tunison	Penobscot	9	96.6	None	3,720
Oswego River	Oswego Harbour	0.66	9/25	1989	Tunison	Penobscot	9	21.6	None	1,560
Oswego River	Oswego Harbour	0.66	9/25	1989	Tunison	Penobscot	9	75.6	None	2,820
Oswego River	Oswego Harbour	0.66	12/18	1989	Tunison	Penobscot	12	4.8	None	210
Oswego	Oswego	0.66	12/18	1989	Tunison	Penobscot	12	24.8	None	6,360
					TOTAL ATLANTIC SALMON FINGERLINGS					14,670
					TOTAL ATLANTIC SALMON YEARLINGS					49,510
					TOTAL ATLANTIC SALMON					64,180
Coho Salmon Yearlings										
North Sandy Creek	Rt. 3 Bridge	0.44	4/3	1988	Salmon R.	Salmon R.	13.5	25.0	None	9,330
South Sandy Creek	Rt. 3 Bridge	0.45	4/3	1988	Salmon R.	Salmon R.	13.5	25.0	None	9,330
Beaverdam Brook	Smolt Release Pond	0.53-8	3/20-5/15 **	1988	Salmon R.	Salmon R.	14.5	13.5	None	90,000
Oswego River	Rt. 104 Bridge	0.66	4/5 & 4/20	1988	Salmon R.	Salmon R.	14	20.1	None	24,190
Sodus Bay	West Pier	0.84	4/5	1988	Salmon R.	Salmon R.	13.5	24.0	None	10,190
Genesee River	Naval Militia Facility	0.117	4/13 & 4/17	1988	Caledonia	Salmon R.	14	13.1	None	10,970
Sandy Creek	Parkway Bridge	0.130	4/14	1988	Caledonia	Salmon R.	14	13.6	None	14,300
Oak Orchard Creek	Twin Bridges	0.138	4/14	1988	Caledonia	Salmon R.	14	13.5	None	10,190
Eighteen Mile Creek	Olcott Harbour	0.148	4/14	1988	Caledonia	Salmon R.	14	13.5	None	10,190
Niagara River	Lewiston Sand Docks	0.158	4/13	1988	Caledonia	Salmon R.	14	11.2	None	8,415
					TOTAL COHO SALMON YEARLINGS					197,105

* Grand Lake Stream Strain from Maine and Little Clear Lake Strain landlocked salmon from New York lumped together.

** Coho fish were stocked in the hatchery smolt release pond on March 20 and allowed to voluntarily migrate until 5/15 when the pond was drained. Hatchery personnel estimated that approx. 1/2 had voluntarily migrated by April 30.

Table 6: (cont'd)

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Coho Salmon Fingerlings										
North Sandy Creek	Rt. 3 Bridge	0.44	10/5	1989	Salmon R.	Salmon R.	9.5	25.3	None	13,350
South Sandy Creek	Rt. 3 Bridge	0.45	10/5	1989	Salmon R.	Salmon R.	9.5	25.3	None	13,350
Oswego River	Rt. 104 Bridge	0.66	10/5	1989	Salmon R.	Salmon R.	9.5	25.3	None	26,700
Sodus Bay	West Pier	0.84	9/27	1989	Caledonia	Salmon R.	9.5	21.0	None	26,700
Genesee River	Naval Militia Facility	0.117	9/25 & 10/3	1989	Caledonia	Salmon R.	9.5	19.2	None	25,000
Sandy Creek	Parkway Bridge	0.130	9/25 & 10/3	1989	Caledonia	Salmon R.	9.5	19.2	None	29,700
Oak Orchard Ck.	Twin Bridges	0.138	9/26 & 10/3	1989	Caledonia	Salmon R.	9.5	19.0	None	29,700
Eighteen Mile Creek	Olcott Harbour	0.148	9/26	1989	Caledonia	Salmon R.	9.5	18.9	None	26,700
Niagara River	Lewiston Sand Docks	0.158	9/27	1989	Caledonia	Salmon R.	9.5	21.0	None	22,250
					TOTAL COHO SALMON FALL FINGERLINGS					213,450
					TOTAL COHO SALMON YEARLINGS					197,105
					TOTAL COHO SALMON					410,555
Chinook Salmon Fingerlings										
Black River	Below Dexter Falls	0.19	5/26	1989	Salmon R.	Salmon R.	4	120	None	70,000
Henderson Bay	Association Island Cut	423	6/12	1989	Salmon R.	Salmon R.	5	93	RV-CWT (60-45-27)	39,700
Henderson Bay	Association Island Cut	423	6/9	1989	Salmon R.	Salmon R.	5	190	None	20,000
					HENDERSON BAY TOTAL					59,700
Lake Ont.	Southwick Beach St. Pk.	523	6/8 & 6/9	1989	Salmon R.	Salmon R.	5	98	RV-CWT (60-45-26)	33,500 *
Lake Ont.	Southwick Beach St. Pk.	523	6/12	1989	Salmon R.	Salmon R.	5	90	None	23,000 **
					SOUTHWICK BEACH STATE PARK TOTAL					56,500
N. Sandy Creek	NY Rt. 3	0.44	5/26	1989	Salmon R.	Salmon R.	4	120	None	90,000
S. Sandy Creek	NY Rt. 3	0.45	5/26	1989	Salmon R.	Salmon R.	4	120	None	90,000

* Reflect estimated 50% mortality of fish stocked on June 8

** Surplus stocking

Table 6: (cont'd)

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Chinook Salmon Fingerlings										
Beaverdam Brook	Salmon River Hatchery	0.53-8	6/8	1989	Salmon R.	Salmon R.	5	93	RV-CWT (60-45-25)	40,000
Beaverdam Brook	Salmon River Hatchery	0.53-8	6/8	1989	Salmon R.	Salmon R.	5	80	None	260,000
					BEAVERDAM BROOK TOTAL					300,000
Salmon R.	NY Rt. 3	0.53	5/25	1989	Salmon R.	Salmon R.	4	110	None	220,000
					SALMON RIVER AND TRIBUTARY TOTAL					520,000
Oswego R.	Oswego Harbour	0.66	5/25	1989	Salmon R.	Salmon R.	4	110	None	225,000
Oswego R.	Oswego Harbour	0.66	5/25	1989	Salmon R.	Salmon R.	4	110	None	16,000 *
					OSWEGO RIVER TOTAL					241,000
Little Sodus Bay	Fair Haven State Park	0.74	5/26	1989	Salmon R.	Salmon R.	4	115	None	180,000
Port Bay	Outlet Channel	0.80	6/9	1989	Salmon R.	Salmon R.	5	90	None	40,000 *
Sodus Bay	Outlet	0.84	6/1	1989	Salmon R.	Salmon R.	5	90	None	180,000
Genesee R.	Old Naval Militia	0.117	5/25	1989	Caledonia	Salmon R.	4	92	None	270,000
Sandy Ck.	Below Rt. 18	0.130	6/6	1989	Salmon R.	Salmon R.	5	95	None	180,000
Oak Orchard Creek	Twin Bridges	0.138	5/26	1989	Caledonia	Salmon R.	4	95	None	270,000
Eighteen Mile Creek	Olcott Harbour	0.148	5/31	1989	Salmon R.	Salmon R.	4	95	None	180,000
Twelve Mile Creek	Wilson Harbour	0.152	5/31	1989	Salmon R.	Salmon R.	4	95	None	60,000
Twelve Mile Creek	Wilson Harbour	0.152	6/9	1989	Salmon R.	Salmon R.	5	90	None	40,000 *
					WILSON HARBOUR TOTAL					100,000
Niagara R.	Lewiston Sand Docks	0.158	5/30	1989	Salmon R.	Salmon R.	4	110	None	225,000
					TOTAL SCHEDULED CHINOOK FINGERLINGS					2,633,200
					TOTAL SURPLUS CHINOOK FINGERLINGS					119,000
					TOTAL CHINOOK FINGERLINGS					2,752,200

* Surplus stocking

Table 6: (cont'd)

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Lake Trout Yearlings										
Lake Ont.	Olcott	708	5/24	1988	Allegheny	Seneca	17	8.0	60-45-21	38,000
Lake Ont.	Olcott	708	5/24	1988	Allegheny	Seneca	17	11.5	60-45-16	40,000
Lake Ont.	Olcott	708	5/24	1988	Allegheny	Superior	17	7.8	60-45-38	30,000
						OLCOTT TOTAL				108,000
Lake Ont.	Hamlin	713	5/19	1988	Allegheny	Seneca	17	9.5	60-45-03	42,100
Lake Ont.	Hamlin	713	5/19	1988	Allegheny	Seneca	17	9.5	60-45-24	38,600
Lake Ont.	Hamlin	713	5/19	1988	Allegheny	Seneca	17	9.0	60-45-23	37,200
Lake Ont.	Hamlin	713	5/23	1988	Allegheny	Seneca	17	11.5	60-45-04	42,400
Lake Ont.	Hamlin	713	5/23	1988	Allegheny	Superior	17	10.0	60-45-15	40,000
Lake Ont.	Hamlin	713	5/23	1988	Allegheny	Superior	17	8.5	60-45-37	30,000
						HAMLIN TOTAL				230,300
Lake Ont.	Sodus	818	5/18	1988	Allegheny	Seneca	17	8.5	60-45-18	38,000
Lake Ont.	Sodus	818	5/18	1988	Allegheny	Superior	17	11.0	60-45-14	40,000
Lake Ont.	Sodus	818	5/18	1988	Allegheny	Superior	17	7.0	60-45-36	30,000
						SODUS TOTAL				108,000
Lake Ont.	Selkirk	623	5/17	1988	Allegheny	Seneca	17	8.5	60-45-19	38,000
Lake Ont.	Selkirk	623	5/17	1988	Allegheny	Superior	17	10.0	60-45-12	40,000
Lake Ont.	Selkirk	623	5/17	1988	Allegheny	Superior	17	7.0	60-45-35	30,000
						SELKIRK TOTAL				108,000
Lake Ont.	Stony	422	5/16	1988	Allegheny	Ontario	17	9.0	60-45-10	40,000
Lake Ont.	Stony	422	5/16	1988	Allegheny	Ontario	17	10.0	60-45-20	38,000
						STONY TOTAL				78,000
Lake Ont.	Stony Point	422	4/28	1988	Caledonia	Seneca	16	6.6	RP	28,000
						STONY POINT TOTAL				28,000
Lake Ont.	Galloo	422	5/23	1988	Allegheny	Ontario	17	9.2	60-45-01	40,000
						GALLOO TOTAL				40,000

Table 6: (cont'd)

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Lake Trout Yearlings										
Lake Ont.	Charity	422	5/24	1988	Allegheny	Ontario	17	10.5	60-44-63	40,000
Lake Ont.	Charity	422	5/25	1988	Allegheny	Seneca	17	10.0	60-45-17	38,000
					CHARITY TOTAL					78,000
					TOTAL YEARLING LAKE TROUT					778,300
Lake Trout Fingerlings										
Lake Ont.	Olcott	708	10/18	1989	Allegheny	Ontario	10	35	60-45-34	60,000
Lake Ont.	Hamlin	713	10/19	1989	Allegheny	Ontario	10	33	60-45-63	61,000
Lake Ont.	Sodus	818	10/19	1989	Allegheny	Superior	10	30	60-45-39	19,500
Lake Ont.	Sodus	818	10/19	1989	Allegheny	Ontario	10	32	60-45-52	30,500
Lake Ont.	Selkirk	623	10/20	1989	Allegheny	Ontario	10	52	60-46-01	61,000
					TOTAL FINGERLING LAKE TROUT					232,000
					TOTAL YEARLING LAKE TROUT					778,300
					TOTAL LAKE TROUT					1,010,300
Brown Trout Yearlings										
Lake Ont.	Henderson Bay	423	4/28	1988	Salmon R.	Rome Lab-Randolph, Rome	16.5	5.8	None	16,720
Lake Ont.	Ray Bay	523	4/27	1988	Salmon R.	Rome Lab-Randolph, Rome	16.5	5.8	None	17,480
Lake Ont.	Montario Pt.	523	4/27	1988	Salmon R.	Rome Lab-Randolph, Rome	16.5	5.8	None	17,480
Lake Ont.	Selkirk Pier	623	5/10	1988	Salmon R.	Rome Lab-Randolph, Rome	17	6.5	LV-Ad	16,500
Lake Ont.	Selkirk Pier	623	5/10	1988	Catskill	Seeforellen/ Catskill	14	8.3	LV	20,000
Lake Ont.	Oswego	721	5/9 & 5/12	1988	Salmon R.	Rome Lab-Randolph, Rome	17	6.5	LV-Ad	16,500
Lake Ont.	Oswego	721	5/9 & 5/12	1988	Catskill	Seeforellen/ Catskill	14	8.0	LV	20,000
Lake Ont.	Fair Haven	720	4/10 & 4/11	1988	Caledonia	Rome, Lab	15.5	4.0	None	27,350
Lake Ont.	Sodus Point	819	4/12	1988	Caledonia	Rome Lab	15.5	3.5	None	25,840
Lake Ont.	Pultneyville	817	4/19 & 4/25	1988	Caledonia	Rome Lab	15.5	4.4	None	19,000

Table 6: (cont'd)

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Brown Trout Yearlings										
Lake Ont.	Pultneyville	817	6/2	1988	Caledonia	Rome Lab	17	2.5	None	2,260
Lake Ont.	Webster	816	4/4 & 4/5	1988	Caledonia	Rome Lab	15	3.6	None	19,000
Lake Ont.	Irondequoit	815	4/5 & 4/6	1988	Caledonia	Rome Lab	15	3.3	None	19,000
Lake Ont.	Rochester	815	4/5	1988	Caledonia	Rome Lab	15	3.4	None	24,300
Lake Ont.	Rochester	815	6/2	1988	Caledonia	Rome Lab	17	2.5	None	2,260
Lake Ont.	Braddock's Point	815	4/4	1988	Caledonia	Rome Lab	15	3.8	None	19,000
Lake Ont.	Hamlin Beach	713	4/3	1988	Caledonia	Rome Lab	15	4.5	None	28,900
Lake Ont.	Hamlin Beach	713	6/2	1988	Caledonia	Rome Lab	17	2.5	None	2,260
Lake Ont.	Point Breeze	711	5/4 & 5/10	1988	Caledonia	Rome Lab	16	3.3	None	30,400
Lake Ont.	Point Breeze	711	6/2	1988	Caledonia	Rome Lab	17	2.5	None	2,260
Lake Ont.	Olcott	708	5/2 & 5/3	1988	Caledonia	Rome Lab	16	3.4	None	30,400
Lake Ont.	Wilson	708	4/10 - 4/20	1988	Caledonia	Rome Lab	15.5	4.1	None	30,400
					TOTAL BROWN TROUT YEARLINGS					407,310
Brown Trout Fingerlings										
Lake Ont.	Oswego Harbour	721	11/28	1989	Caledonia	Rome Lab	11	7.5	None	37,950
					TOTAL BROWN TROUT FINGERLINGS					37,950
					TOTAL BROWN TROUT YEARLINGS					407,310
					TOTAL BROWN TROUT					445,260
Rainbow Trout Yearlings										
Lake Ont.	Henderson Bay	423	4/24, 4/26	1988	Caledonia	Nashua	12	3.1	None	18,790
Lake Ont.	Selkirk Shores State Park	623	4/19, 20 & 26	1988	Caledonia	Nashua	12	4.0	None	19,250
Lake Ont.	Sodus Point	819	4/13	1988	Caledonia	Nashua	12	3.3	None	13,400
Lake Ont.	Webster	0.84	4/5	1988	Caledonia	Nashua	12	4.4	None	7,700
Lake Ont.	Hamlin Beach State Park	713	4/3	1988	Caledonia	Nashua	12	4.0	None	15,400
Lake Ont.	Olcott Harbour	708	4/26, 4/27	1988	Caledonia	Nashua	12	3.3	None	9,625
Lake Ont.	Wilson Harbour	707	4/26, 4/27	1988	Caledonia	Nashua	12	3.3	None	9,625
					TOTAL YEARLING RAINBOW TROUT					93,790

Table 6: (cont'd)

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Rainbow Trout Fingerlings										
Niagara R.	Lewiston	0.158	11/2	1989	Caledonia	Nashua	7	21	None	25,000 *
					TOTAL FINGERLING RAINBOW TROUT					25,000
					TOTAL YEARLING RAINBOW TROUT					93,790
					TOTAL RAINBOW TROUT					118,790
Steelhead Trout Yearlings										
Black River	Dexter	0.19	4/25	1988	Caledonia	Washington-Salmon River	10	8.2	None	16,770
Stony Ck.	Stony Creek Road Bridge	0.40	4/18	1988	Salmon R.	Washington-Salmon River	10	22.0	None	19,000
South Sandy Ck.	Below NY Rt. 3	0.44	4/18, 4/25	1988	Salmon R.	Washington-Salmon River	13	8.9	None	20,970
Beaverdam Brook	Salmon R. Hatchery	0.53-8	4/30	1988	Caledonia	Washington-Salmon River	10	10.0	LV	45,000
Beaverdam Brook	Salmon R. Hatchery	0.53-8	5/15	1988	Salmon R.	Washington-Salmon River	14	8.0	LV	45,000
Spring Bk. Reservoir	Reservoir	0.53-2-P.6	4/6	1988	Salmon R.	Washington-Salmon River	13	13.2	LV	10,000
Orwelt Brook	Lower 3 Bridges	0.53-6	4/6	1988	Salmon R.	Washington-Salmon River	13	13.2	LV	10,000
Salmon R.	Pineville	0.53	4/6	1988	Salmon R.	Washington-Salmon River	13	13.2	LV	5,000
Salmon R.	Co. Rt. 2A	0.53	4/6	1988	Salmon R.	Washington-Salmon River	13	13.2	LV	5,000
					SALMON RIVER SYSTEM TOTAL					120,000
Oswego R.	Oswego Harbour	0.66	4/17	1988	Salmon R.	Washington-Salmon River	10	22.0	None	19,000
Oswego R.	Oswego Harbour	0.66	4/24	1988	Caledonia	Washington-Salmon River	10	9.8	None	12,600
					OSWEGO RIVER TOTAL					31,600

* Indicates surplus stocking

Table 6: (cont'd)

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Steelhead Trout Yearlings										
Maxwell Ck.	Mouth to Trib. 2	0.85	4/20	1988	Salmon R.	Washington-Salmon River	10	22.0	None	19,000
Irondequoit Creek	Audubon Property	0.108	4/20	1988	Caledonia	Washington-Salmon River	10	10.7	None	10,000
Irondequoit Creek	Outlet Channel	0.108	4/21	1988	Caledonia	Washington-Salmon River	10	8.9	None	10,140
					IRONDEQUOIT CREEK TOTAL					20,140
Genesee R.	Old Naval Militia	0.117	4/17	1988	Caledonia	Washington-Salmon River	10	10.2	None	16,770
Salmon Ck.	Lower portion	0.125	4/18	1988	Caledonia	Washington-Salmon River	10	10.1	None	8,390
Sandy Ck.	below Rt. 18	0.130	4/14, 4/18	1988	Caledonia	Washington-Salmon River	10	10.1	None	11,130
Oak Orchard Ck.	Twin Bridges	0.138	4/14, 4/17	1988	Caledonia	Washington-Salmon River	10	11.0	None	16,770
Oak Orchard Ck.	Twin Bridges	0.138	5/5	1988	Caledonia	Washington-Salmon River	11	7.8	None	12,300
					OAK ORCHARD CREEK TOTAL					29,070
Keg Ck.	Rt. 18 Bridge	0.148	4/14	1988	Caledonia	Washington-Salmon River	10	9.9	None	9,300
E. Branch Twelve Mile Creek	Near Mouth	0.152	4/18	1988	Caledonia	Washington-Salmon River	10	8.9	None	11,150
Twelve Mile Creek	Rt. 18 Bridge	0.152A	4/19	1988	Caledonia	Washington-Salmon River	10	8.9	None	11,150
Niagara R.	Lewiston Sand Docks	0.158	4/19	1988	Salmon R.	Washington-Salmon River	10	22.0	None	19,000
Niagara R.	Lewiston Sand Docks	0.158	4/20	1988	Caledonia	Washington-Salmon River	10	10.7	None	20,970
					NIAGARA RIVER TOTAL					39,970
					STEELHEAD YEARLING TOTAL					384,410

Table 6: (cont'd)

Area Stocked	Location	Grid/ Key	Date Stocked	Year Class	Hatchery Reared	Strain or Egg Source	Age in Months	# Fish/ Pound	Marks Applied	Number Stocked
Steelhead Trout Fingerlings										
Black River	Below Dexter Falls	0.19	9/[illegible]	1989	Salmon R.	Washington-Salmon River	5	80	None	37,500
Little Sodus Bay	Fair Haven Beach State Pk.	0.74	9/19	1989	Salmon R.	Washington-Salmon River	5	80	None	37,500
					SURPLUS STEELHEAD FINGERLING TOTAL					75,000
					TOTAL YEARLING STEELHEAD					384,410
					TOTAL STEELHEAD					459,410
Walleye Fingerlings										
Niagara R.	Lewiston	0.158	5/19, 20, 21	1989	NRAA* Ponds	Constantia	4	2-3"	None	1,200
Niagara R.	Lewiston	0.158	7/19, 20, 21	1988/ 89 **	NRAA Ponds	Constantia	4-16	6-14"	None	100
Lake Ont.	Sodus Bay	0.84	7/1	1989	Sanford Bait Farms***	Constantia	4	2"	None	35,000
Lake Ont.	Sodus Bay	0.84	Early Sept.	1989	Sanford Bait Farms	Constantia	6	4-5"	None	500
Lake Ont.	Port Bay	819	7/1	1989	Sanford Bait Farms	Constantia	4	2"	None	9,000
Lake Ont.	Port Bay	819	Early Sept.	1989	Sanford Bait Farms	Constantia	6	3-10"	None	5,000
Lake Ont.	Port Bay	819	Early Oct.	1989	Sanford Bait Farms	Constantia	7	4-6"	None	1,000
Lake Ont.	Blind Sodus Bay	720	7/2	1989	Sanford Bait Farms	Constantia	4	2-3"	None	6,000
Lake Ont.	Little Sodus Bay	720	7/2	1989	Sanford Bait Farms	Constantia	4	2-3"	None	14,000
					TOTAL WALLEYE					71,800

* Niagara River Anglers Association - 8 ponds, 1/2 acre each
** Represents cannibals from 1989 and leftover fish from 1988
*** Sanford Bait Farms - 3 ponds, 1/2 acre each

Table 7: Important deviations from the proposed stocking numbers by OMNR and DEC in 1989.

Species	Agency	Number (in thousands)	Reason
Lake Trout	DEC	- 252Y + 52F	Attempting to produce recently required strains is taking time.
	OMNR	- 26Y	Hatchery shortfall, closing in on goal of 1,150,000 yearlings.
Coho	DEC	- 123Y + 213F	Policy change by Great Lakes Fisheries Section allows large fingerlings to be stocked replacing some yearlings.
	OMNR	+ 44Y + 7F	Better than expected survival.
Chinook	OMNR	- 109F	Hatchery (Ringwood) cannot meet 650,000 chinook fingerling target without expansion of early rearing facility.
Rainbow Trout	OMNR	- 57Y	Yearling shortfall. Unmarked fingerlings were refused for stocking into Lake Ontario.
Steelhead	DEC	+ 54Y + 75F	Better than anticipated survival of all year classes.
Skamania	DEC	- 82F	No yearlings available due to disease.
Brown Trout	DEC	- 92Y + 38F	Statewide shortage of yearlings and stocking of fingerlings to create hatchery space.
	OMNR	- 75Y	Hatchery shortfall.
Atlantic Salmon	DEC	- 49Y, + 50Y + 15F	Hatchery renovation underway. Stocking requirement is for landlocked salmon and these were provided by federal hatcheries.
	OMNR	+ 11Y + 15F	Better than expected survival.

Legend: Y: Yearlings, stocked between January and June, usually 5" to 9"
F: Fall fingerlings, stocked between September and December usually 3-1/2" to 6"
f: Spring fingerlings, stocked May and June usually 2-1/2" to 3".

Table 8: Proposed 1990 stocking in Province of Ontario waters of Lake Ontario.

Species	Location	Quantity	Age
Coho Salmon	Credit River	100,000	Yearling
	Bronte Creek	30,000	Yearling
	Martindale Pond	30,000	Yearling
	Credit River	50,000	Fall Fingerling
	Bronte Creek	10,000	Fall Fingerling
	Martindale Pond	20,000	Fall Fingerling
		240,000	
Chinook Salmon	Credit River	200,000	Spring Fingerling
	Hamilton Harbour	75,000	Spring Fingerling
	Bronte Creek	75,000	Spring Fingerling
	Port Dalhousie	150,000	Spring Fingerling
	Cobourg Area	40,000	Spring Fingerling
	Oshawa Creek	30,000	Spring Fingerling
	Bowmanville Creek	30,000	Spring Fingerling
	Wellington	50,000	Spring Fingerling
		650,000	
Brown Trout	12 Mile Creek	35,000	Yearling
	Jordan Harbour	35,000	Yearling
	Collins Bay	55,000	Yearling
	Parrott's Bay	55,000	Yearling
	Bronte Creek	35,000	Yearling
	50 Mile Point	35,000	Yearling
	Ganaraska River	25,000	Yearling
	Oshawa Creek	25,000	Yearling
	Humber River	25,000	Yearling
	Rouge River	30,000	Yearling
	Duffins Creek	25,000	Yearling
	Toronto Island	30,000	Yearling
	Bluffer's Park	25,000	Yearling
		435,000	
Lake Trout	50 Mile Point	200,000	Yearling
	Port Hope	200,000	Yearling
	Scotch Bonnet Shoal	250,000	Yearling
	Charity-Main Duck Sh.	500,000	Yearling
		1,150,000	
Rainbow Trout	Credit River	100,000	Yearling
	Bronte Creek	75,000	Yearling
		175,000	
Atlantic Salmon	Credit River	40,000	Yearling
	Wilmot Creek	10,000	Yearling
		50,000	
CANADIAN TOTAL ALL SPECIES		2,700,000	

Table 9: Proposed 1990 stocking of New York waters in Lake Ontario.

Region	Location	Key	Number	Age
Chinook Salmon				
6	Southwicks Beach	523	50,000	4 months
6	Associated Island	423	60,000	4 months
6	Stony Creek	0.40	35,000	4 months
6	North Sandy Creek	0.45	90,000	4 months
6	South Sandy Creek	0.45	90,000	4 months
7	Salmon River	0.53	300,000	4 months
7	Lower Salmon River	0.53	270,000	4 months
7	Oswego River	0.66	225,000	4 months
7	Little Sodus Bay	0.73	180,000	4 months
8	Sodus Bay	0.84	180,000	4 months
8	Genesee River	0.117	270,000	4 months
8	Sandy Creek	0.130	180,000	4 months
8	Oak Orchard Creek	0.138	270,000	4 months
9	Eighteen Mile Creek	0.148	180,000	4 months
9	Twelve Mile Creek	0.152	60,000	4 months
9	Lower Niagara River	0.157	260,000	4 months
		TOTAL	2,700,000	
Coho Salmon				
6	North Sandy Creek	0.45	15,000	Yearling
6	South Sandy Creek	0.45	15,000	Yearling
7	Salmon River	0.53	90,000	Yearling
7	Oswego River	0.66	30,000	Yearling
8	Sodus Creek	0.84	30,000	Yearling
8	Genesee River	0.117	25,000	Yearling
8	Sandy Creek	0.130	30,000	Yearling
8	Oak Orchard Creek	0.138	30,000	Yearling
9	Eighteen Mile Creek	0.148	30,000	Yearling
9	Niagara River	0.157	25,000	Yearling
		TOTAL	320,000	
Atlantic Salmon				
6	Lindsey Creek	0.48	11,000	Yearling
7	Little Sandy Creek	0.50	20,000	Yearling
8	Irondequoit Creek	0.108	18,000	Yearling
		TOTAL	49,000	

Table 9: (cont'd)

Region	Location	Key	Number	Age
Brown Trout				
6	Montario Point	523	23,000	Yearling
6	Ray Bay	523	23,000	Yearling
6	Henderson Bay	424	22,000	Yearling
7	Fairhaven Beach St. Pk.	720	35,000	Yearling
7	Oswego Harbour	721	38,000	Yearling
7	Selkirk Shores St. Pk.	623	35,000	Yearling
8	Hamlin Beach St. Pk.	713	38,000	Yearling
8	Irondequoit	815	25,000	Yearling
8	Rochester at Kodak	815	32,000	Yearling
8	Braddocks	815	25,000	Yearling
8	Webster	816	25,000	Yearling
8	Point Breeze	711	40,000	Yearling
8	Sodus Point	819	34,000	Yearling
8	Pultneyville	817	25,000	Yearling
9	Wilson	707	40,000	Yearling
9	Olcott	708	40,000	Yearling
		TOTAL	500,000	
Lake Trout				
6	Dablon Point	322-323	120,000	Yearling
6	Dablon Point	322-323	50,000	Yearling
6	Stony Point	422-423	120,000	Yearling
6	Stony Point	422-423	50,000	Yearling
6	Stony Point	422-423	60,000	Fingerling
7	Selkirk	623	120,000	Yearling
7	Selkirk	623	50,000	Yearling
7	Selkirk	623	30,000	Fingerling
8	Hamlin Beach	713	120,000	Yearling
8	Hamlin Beach	713	50,000	Yearling
8	Hamlin Beach	713	30,000	Fingerling
8	Sodus	819	120,000	Yearling
8	Sodus	819	50,000	Yearling
8	Sodus	819	30,000	Fingerling
9	Niagara	806	120,000	Yearling
9	Niagara	806	50,000	Yearling
9	Niagara	806	30,000	Fingerling
		TOTAL	1,020,000 180,000	Yearling Fingerling

Table 9: (cont'd)

Region	Location	Key	Number	Age
Washington Steelhead				
6	Black River	0.19	20,000	Yearling
6	South Sandy Creek	0.45	25,000	Yearling
7	Salmon River	0.53	120,000	Yearling
7	Oswego River	0.66	15,000	Yearling
8	Genesee River	0.117	20,000	Yearling
8	Irondequoit Creek	0.108	24,000	Yearling
8	Salmon Creek	0.125	10,000	Yearling
8	Sandy Creek	0.130	13,300	Yearling
8	Oak Orchard Creek	0.138	20,000	Yearling
9	Keg Creek	0.146	11,100	Yearling
9	E. Br. Twelve Mile Creek	0.152	13,300	Yearling
9	Twelve Mile Creek	0.152A	13,300	Yearling
9	Lower Niagara River	0.157	25,000	Yearling
		TOTAL	330,000	
Skamania Steelhead				
6	Stony Creek	0.40	18,000	Yearling
7	Catfish Creek	0.60	10,000	Yearling
7	Oswego River	0.66	18,000	Yearling
8	Maxwell Creek	0.85	18,000	Yearling
9	Niagara River	0.157	18,000	Yearling
		TOTAL	82,000	
Domestic Rainbow Trout				
6	Henderson Bay	424	25,000	Yearling
7	Selkirk Shores St. Pk.	623	25,000	Yearling
8	Hamlin Beach St. Pk.	713	20,000	Yearling
8	Hamlin Beach St. Pk.	713	23,000	Fingerling
8	Sodus	819	20,000	Yearling
9	Wilson	707	12,500	Yearling
9	Olcott	708	12,500	Yearling
		TOTAL	115,000	Yearling
			23,000	Fingerling
	Total Salmon and Trout Requested		5,319,000	

Salmonid Angler Survey of the Western and Central Basins of Lake Ontario, 1989

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Lake Ontario Fisheries Unit, 1989 Annual Report, L0A 90.1 (Chapter 12)

The survey provided data on anglers that launch their boats daily at public access points on Lake Ontario from Niagara to Wellington, charter boat operators belonging to charter associations, unaffiliated charter boat operators and unguided marina based anglers (moored boat anglers). The estimated total effort and harvest in the Central Region by launch daily anglers were 635,565 rod-hr and 55,715 salmonids. In Napanee District, the estimated total effort and harvest by launch daily anglers were 76,379 rod-hr and 8,886 salmonids. Chinook and rainbow trout dominated the harvest. Coho, lake trout, and brown trout were of less importance but, as a group, formed a significant portion of the catch. The charter boat effort was estimated at 371,116 rod-hr in the Central Region, and 28,864 rod-hr in the Napanee District. The corresponding harvest was 67,818 and 5,097 salmonids, respectively. Marina based unguided angler effort and harvest were estimated at 310,172 rod-hr and 36,072 salmonids. The effort associated with the charter boats and moored boats is similar to the effort of launch daily anglers, but the harvest by charter boats and moored boats exceeds the total for the launch daily anglers. The charter boat fishery in Kingston basin of Napanee District was estimated to be 1.4 times greater in effort than the central and western basin portions of Napanee District. The remaining components of the salmonid fishery are the shore fishery and the Kingston Basin fishery and these were not sampled in 1989, but indications are that these components may be significant in size. From 1986 to 1989, fishing effort of launch daily anglers in the Central Region was relatively constant. Total salmonid harvest peaked in 1986, but has remained relatively constant from 1987 to 1989. Trends in the Toronto Star Derby CUE show a continuing decline in overall salmonid catch rates, largely due to decreases in rainbow trout and coho.

Recommendations

1. Survey the shore angler fishery and the Kingston basin fishery to complete the survey of all components of Ontario's Lake Ontario salmonid fishery.
2. Continue to periodically monitor the charter and unguided marina based fishery.
3. Develop independent sampling programs to measure salmonid relative abundance and angling selectivity.
4. Determine the proportion of naturally reproduced rainbow trout in the harvest.
5. Investigate methods to recognize stocked *vs* naturally reproduced chinook.

Introduction

The salmonid fishery in the western basin of Lake Ontario has been monitored since 1977. Early assessments concentrated on monitoring the "launch daily" anglers in the individual fishing derbies. Full basin wide surveys were not completed until 1985 (Daniels and Savoie, 1986) and have since expanded with the expansion of the fishery.

Past surveys have concentrated on anglers that launch their boats daily at public access points in the western basin of Lake Ontario from Niagara to Cobourg. In 1989, the scope of the survey was expanded to include the Napanee Ontario Ministry of Natural Resources (OMNR) administrative district (Brighton and Wellington), a mail/telephone survey of charter boat operators belonging to charter associations, unaffiliated charter boat operators and marina based unguided anglers (moored boat anglers). The Napanee District fishery straddles the Scotch Bonnet sill which divides the central and western basins of Lake

Table 1. Access points on Lake Ontario that were surveyed on a complete day schedule in 1989.

Code	Access Point	District	Apr	May	Jun	Jul	Aug	Sep
4	St. Cath. G&F Assoc. Ramp	Niagara	X	X				
11	Fifty Mile Point (HRCA)	Cambridge	X	X				
19	Port Credit Public Docks	Maple			X	X	X	X
24	Bluffer's Park (MTRCA)	Maple			X	X	X	X
36	Ontario Street Ramp	Napanee					X	
37	Brighton Marina	Napanee			X	X	X	
38	Gosport Government Ramp	Napanee			X	X		
39	Wellington Gov't Ramp	Napanee			X	X	X	

Table 2. Access points on Lake Ontario that were surveyed on a roving schedule in 1989.

Code	Access Point	District	Apr	May	Jun	Jul	Aug	Sep
4	St. Cath. G&F Assoc. Ramp	Niagara			X	X	X	X
7	Campbell's Boats	Niagara			X	X	X	X
9	Foran's Marine	Niagara			X	X	X	X
11	Fifty Mile Point (HRCA)	Cambridge			X	X	X	X
13	Mohawk Canoe Club	Cambridge			X	X	X	X
14	Bronte Beach Park	Cambridge			X	X	X	X
19	Port Credit Public Docks	Maple	X	X				
20	Marie Curtis Park (MTRCA)	Maple	X	X				
21	Humber Bay West Pk (MTRCA)	Maple	X	X				
28	Whitby Government Ramp	Lindsay	X	X	X	X	X	X
31	Bowmanville HBR CA (CLOCA)	Lindsay	X	X	X	X	X	X
33	Port Hope Marina	Lindsay	X	X	X	X	X	X

Ontario. The lake-wide shore fishery and activity in Kingston basin were not surveyed. The Kingston basin was thought to be a growing but relatively minor component of the salmonid fishery, and in 1987 was comparable in effort and harvest to the western and central basins of Napanee District (Mathers, 1988). The magnitude of the shore angler effort and harvest has remained unknown, but indications from District biologists were that it may be locally significant in some areas. This report has detailed the results of the 1989 survey and the trends in the fishery.

Survey Design for Launch Daily Anglers

The angler survey design was based on access point surveys of anglers that launch their boats daily from 8 access points surveyed during selected months (Table 1). These access points, and an additional 5 other access points were were sampled on a half-day roving schedule during alternate months (Table 2) to provide complete temporal and spatial coverage of the western and central basins of Lake Ontario (Fig. 1). Detailed instruction for the 1989 angler survey technicians are on file at the Ontario Ministry of Natural Resources, Central Region, Aurora.

A total of 15 spatial and temporal strata were designated (Table 3) for expansion of estimates of effort, catch, and harvest. Napanee District (Brighton and Wellington) was only surveyed during June to August, because anecdotal information suggested that effort was extremely low in other months. This stratification was efficient and allowed for separate estimates of survey statistics by OMNR administrative districts. Results are sometimes presented by OMNR administrative region for ease of comparison with past surveys.

For the major access points (Table 1), three time periods were designated (11:00-14:00, 14:00-17:00, and 17:00-20:00) based on previous surveys that showed that few anglers return to the access points outside of these times. During April, these time periods began one hour earlier and ended at 19:00. At these access points, a surveyor sampled all three time periods in a single day. For the roving survey access points (Table 2) two time periods were designated; 11:00-14:30 and 15:30-19:00. On any given sampling day access points were sampled during one or both time periods. Sampling access points and time periods were determined in an unbiased manner.

Table 3. Spatial and temporal stratification used for expansion of estimats of angling statistics from the Lake Ontario Salmonid Angler Survey in 1989.

Region	District	Months					
		Apr	May	Jun	Jul	Aug	Sep
Central	Niagara	A	C	G	G	G	G
Central	Cambridge	B	D	H	H	H	H
Central	Maple	E	E	I	J	K	L
Central	Lindsay	F	F	F	F	F	F
Eastern	Napanee			M	N	O	

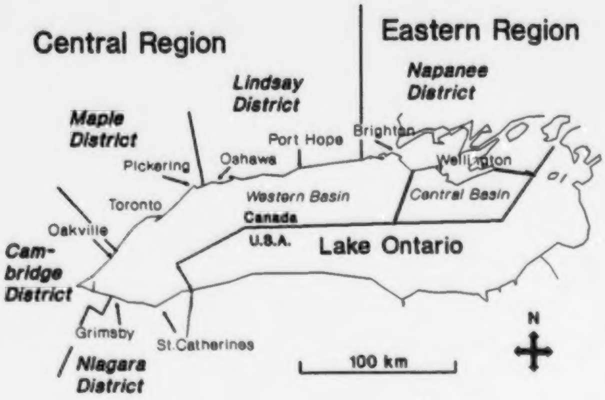


FIG. 1. A map of Lake Ontario and OMNR administrative districts and regions.

Charter boat anglers using trailer ramps were tabulated but not included in the activity counts. Included with the hourly activity count was the observed number of non-fishing boats using the trailer ramp. Daily counts of both the number of fishing boats and non-fishing boats were determined and stratum totals used to calculate the proportion of total trailers used by fishing boats only.

An estimate of the number of fishing parties that did not trailer their boats by the end of the fishing day was determined by counting the number of trailers remaining in the parking lot at 20:00 (19:00 in April). These numbers were used to derive a monthly estimate of the activity missed. Monthly estimates were used rather than stratum estimates, as missed activity is largely a function of day length. From past surveys, missed activity was observed to be higher during weekdays, and separate estimates were derived for each day-type within a month.

Survey results from the 8 major access points were expanded to effort for the entire western and central basins (Niagara to Wellington) of Lake Ontario based on counts of boat trailers on weekends at all access points (Table 4). In

Table 4. Relative fishing activity (%) by month during 1989 at all OMNR Central Region Lake Ontario access points based on trailer counts corrected for the proportion of non-fishing boats.

Code	Access Points	April	May	June	July	Aug	Sept
0	Old Boat Works	4.77	4.80	0.89	0.30	0.32	0.77
4	Port Dalhousie	30.45*	25.58*	6.94	2.59	5.32	6.68
5	Snug Harbour	0.00	0.00	0.00	0.00	0.00	0.00
6	Becon Motor Inn	1.21	0.36	0.40	0.06	0.13	0.44
7	Cambell's Boats	13.79	8.77	3.87	1.10	0.86	1.53
8	Grimsby Municipal Ramp	3.71	2.28	0.50	0.08	0.35	0.33
9	Foran's Marine	6.06	6.13	1.98	0.44	0.99	1.64
10	Lakecourt Marina	2.20	2.64	0.20	0.30	0.30	0.22
11	HRCA 50 Point	14.06*	12.18*	8.75	3.53	3.64	5.17
12	Fisherman's Wharf	2.23	8.28	8.95	4.22	3.78	7.13
13	HRCA Canoe Club	4.01	7.70	4.89	3.64	4.06	7.59
14	Bronte Beach Park	7.19	6.82	9.89	4.89	5.81	11.61
16	Coronation Park	0.06	0.58	0.00	0.03	0.00	0.00
17	Oakville (downstream)	0.76	2.24	4.37	2.69	2.88	2.53
18	Oakville (upstream)	0.25	0.88	0.10	0.03	0.00	0.00
19	Pt. Credit Public Docks	2.31	3.68	6.35*	6.88*	12.30*	17.70*
19A	Lake Promenade Park	0.65	0.24	0.81	2.17	5.14	5.48
20	MTRCA Marie Curtis Park	0.18	0.12	1.55	2.51	5.66	1.91
21	MTRCA Humber Bay	0.32	0.72	5.54	11.26	9.87	5.48
23	MTRCA Ashbridges Bay	0.11	0.54	3.47	7.66	5.66	2.67
24	MTRCA Bluffer's Park	0.94	1.99	13.14*	20.18*	15.79*	7.64*
26	Frenchman's Bay East	1.00	0.22	0.40	0.15	0.07	0.29
27	Whitby Marina	0.00	0.00	0.00	0.37	0.11	0.00
28	Whitby Government Ramp	0.94	1.68	5.98	8.67	5.43	5.57
29	Oshawa Marina	0.00	0.11	2.13	4.02	2.88	2.35
31	CLOCA Port Darlington	0.60	0.67	3.72	6.86	4.86	2.49
33	Port Hope	1.67	0.67	2.79	3.65	2.70	2.20
34	Cobourg	0.53	0.11	2.39	1.73	1.08	0.59
Total Of Surveyed Access Points		44.51	37.76	19.49	27.06	28.09	25.34

addition to the 25 access points sampled in the western basin in 1988 (Stewart and Savoie 1989), three new access points were added; Fisherman's Wharf (Burlington), Lake Promenade Park (Port Credit), and Frenchman's Bay East (Pickering) (Table 4). As the new launch facility at Fisherman's wharf was not known until the start of the field season, some counts in April were estimated from the proprietor's daily receipts. In Napanee District, trailer counts were done at 5 access points, with the Wellington Beach access point only being surveyed from mid-July to August (Table 5). Trailers counts were done at each access point each weekend, alternating systematically between Saturday and Sunday during the hours of 10:00-1400. Two major routes in the Central Region and one in the Napanee District were required to complete the counts and starting locations were varied to reduce bias due to the time of day the count was completed.

The trailers counts were used to determine the relative effort across access points in each stratum. Trailer counts were corrected based on stratum estimates of the proportion of non-fishing boats. From these data the proportion of total fishing effort occurring at each access point in each stratum was determined. An expansion factor was calculated for each stratum based on the proportion of the total effort represented by the surveyed access points. Monthly estimates of missed effort were applied to effort estimates before determining stratum totals.

Corrections were applied to account for fishermen returning to the access point after 2000 hours, and estimates of the proportion of trailers counted that were used for non-fishing boats. From angler interviews, observed species catch rate (CUE) and harvest rate (HUE) were estimated for each stratum and multiplied by effort to estimate catch and harvest. Catch and harvest rates were estimated separately for weekends and weekdays.

Survey Design for Charter Boat and Marina Based Anglers

Major marinas in the western basin of Lake Ontario were also surveyed on a roving schedule (Table 6). Time periods were the same as those designated for the roving survey of launch daily anglers. Surveyors positioned themselves in known areas of charter boat activity and interviewed fishing boats returning to port. From interviews the boat was classified as either a unguided angling boat (moored boat), charter boat association (CBA) boat, or unaffiliated charter boat. In the Napanee District charter boat operators were contacted at the same access points used by launch daily anglers. Interviews determined CBA membership but it was redundant to classify unguided angling boats at the Napanee District access points. Interviews also provided information on number of rods, number of anglers, trip duration, and species catch and harvest rates.

From CBA membership lists provided by the Ontario Charter Boat Association, Independent Charter Boat Association, Scarborough Charter Boat Association, and the Eastern Lake Ontario Charter Boat Association a random sample of 81 (28%) CBA members were selected. These members were sent a post card asking for the number of boat trips conducted by month and the marina used. Nonrespondents were contacted by telephone and the information was recorded directly from the telephone interview. Based on this survey, the total number of boat trips for all CBA members was estimated. Information provided on port use allowed for partitioning of activity into the Central Region and Napanee District. The total number of boat trips was expanded to fishing effort (rod-hr), and species catch rates based on interview information. Unaffiliated charter boat effort and unguided marina based effort were estimated by the proportion of total observed effort in each angling component determined from the total interview sample.

From a sub-sample of surveyed anglers, each fish landed was identified and measured. A size stratified sub-sample of these fish was weighed. Seasonal length-weight curves were derived and applied to length measurements to estimate weight of each fish harvested. Fin clips were recorded and the percentage of fin regeneration was estimated. Biological characteristics of sampled fish were not separated by fishery component. Sampling intensity in the western basin varied between strata, requiring that mean weights, lengths and clip frequency distributions be weighted by estimated harvest.

The analysis of the access point surveys was done using CREESYS (Lester and Trippel, 1985) to provide estimates of angler effort, species catch, and harvest for each surveyed

Table 5. Relative fishing activity (%) by month during 1989 at all Napanee District Lake Ontario access points based on trailer counts corrected for the proportion of non-fishing boats.

Code	Access point	June	July	Aug	July/Aug[1]
36	Ontario Street Ramp	54.8	49.8	58.6*	43.9
37	Gosport Government Ramp	1.6*	9.9*	10.0	11.3
38	Brighton Marina	3.2*	10.7*	10.7*	9.8
39	Wellington Government Ramp	40.3*	29.6*	20.7*	25.6
40	Wellington Beach	-	-	-	9.5
Total of surveyed access points		45.1	50.2	90.0	

[1] Based on a partial survey of Wellington Beach in July and August.

Table 6. Marinas on Lake Ontario that were surveyed on a roving schedule in 1989.

Marina	District	Apr	May	Jun	Jul	Aug	Sep
Foran's Marina	Niagara	X	X	X	X	X	X
Lakecourt Marina	Niagara	X	X	X	X	X	X
Snug Harbour	Niagara	X	X	X	X	X	X
Bronte Municipal	Cambridge	X	X	X	X	X	X
Oakville Municipal	Cambridge	X	X	X	X	X	X
Harbour Marina	Maple	X	X	X	X	X	X
East Shore Marina	Maple	X	X	X	X	X	X
Bluffer's Park Marina	Maple	X	X	X	X	X	X
Oshawa Marina	Lindsay			X	X	X	X
Whitby Marina	Lindsay			X	X	X	X

Table 7. Summary of the launch daily angling statistics in Lake Ontario by OMNR administrative district during 1989.

Angling statistic	District				Central Region Total	Napanee District
	Niagara	Cambridge	Maple	Lindsay		
Effort (rod-hr)	105,958	152,984	280,699	95,924	635,565	76,379
Salmonid catch	17,496	21,947	46,153	22,986	108,582	10,488
Salmonid harvest	5,634	12,258	25,081	12,742	55,715	8,886
Catch rate (No./hr)	0.165	0.143	0.164	0.240	0.171	0.137
No. hr. to catch a fish	6.1	7.0	6.1	4.2	5.9	7.3

Table 8. Summary of salmonid angling statistics in Lake Ontario by fishery component during 1989.

Angling statistic	Launch daily	Charters			Moored	Total
		Central Region	Napanee District	Total		
Effort (rod-hr)	714,934	371,116	28,864	399,980	310,172	1,425,086
Salmonid catch	119,070	79,899	5,329	85,228	60,174	264,472
Salmonid harvest	64,601	67,818	5,097	72,915	36,072	173,588
Catch rate (No./hr)	0.167	0.215	0.185	0.213	0.194	0.186
No. hr. to catch a fish	6.0	4.7	5.4	4.7	5.2	5.4

access point. For the roving access points, species CUE and HUE were summarized using SAS (Statistical Analysis System).

Angling Effort and Harvest

In the Central Region, activity during spring was concentrated on the south shore, primarily at Port Dalhousie, Fifty Mile Point, and Campbell's Boats (Table 4). In June activity was concentrated in the area between Fifty Mile Point and Bronte Beach Park, and also near Bluffer's Park. During summer activity was more evenly distributed among access points but the Toronto and Port Credit areas predominated. The fishing activity represented by the surveyed access points in the Central Region ranged from 19.5% to 44.5%. In past years, survey stratification was by month, thus relative monthly activity by access point was reported for reference only. Expansion factors used for this report cannot be directly derived from Table 4.

In the Napanee District activity was predominantly associated with the Ontario Street ramp (Brighton) and the Wellington Government ramp (Table 5). The total fishing activity represented by the surveyed access points in the central basin ranged from 45.1% to 90.0%. An additional expansion factor was determined for the Napanee District based on the partial trailer count survey of Wellington Beach in July and August. This access point contributed 9.5% additional effort (Table 5).

The estimated total effort and harvest in the Central Region by launch daily anglers were 635,565 rod-hr and 55,715 salmonids (Table 7). Most of the fishing activity was in Maple district. In Napanee District, the estimated total effort and harvest by launch daily anglers were 76,379 rod-hr and 8,886 salmonids (Table 8).

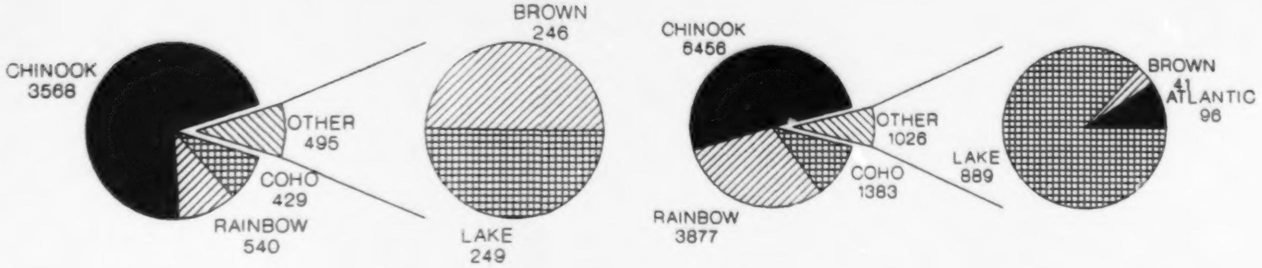
Estimates of launch daily angler effort by district are similar to 1988 (Stewart and Savoie 1989) with the exception of Cambridge District which increased by about 50%. This may have been due to the opening of a new access point under the Burlington bridge (Fisherman's Wharf), and improvement to the Halton Region Conservation Authority ramp in the same vicinity. Catch rates were similar to 1988 with Niagara and Cambridge districts declining slightly, Maple district remaining the same, and Lindsay district increasing.

Species composition of the harvest by launch daily anglers varies across districts (Fig. 2). Chinook and rainbow trout dominated the harvest. Coho, lake trout, and brown trout were of less importance but, as a group, formed a significant portion of the catch. Atlantic salmon were harvested in small numbers in Cambridge, Lindsay, and Maple districts only.

The charter boat effort was estimated at 371,116 rod-hr in the Central Region, and 28,864 rod-hr in the Napanee District (Table 8). The corresponding harvest was 67,818 and 5,097 salmonids, respectively. Marina based unguided angler effort and harvest were estimated at 310,172 rod-hr and 36,072 salmonids (Table 8). The high level of effort associated with the previously unsurveyed moored boat component is striking. Our marina survey methods were targeted towards charter boat operators. Despite this bias we observed that most fishing boat traffic at marinas was unguided anglers. We conclude that fishing effort by moored boat anglers, while less than the launch daily angling component, is at least on par with the charter fishery. The effort (710,152 rod-hr) associated with the charter boats and

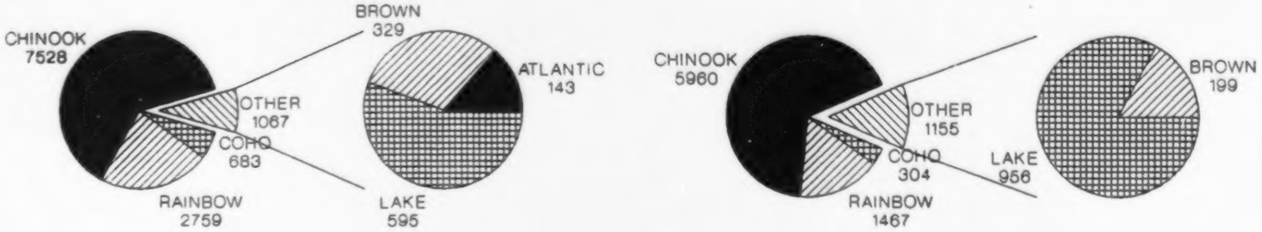
a) Niagara District

d) Lindsay District



b) Cambridge District

e) Napanee District



c) Maple District

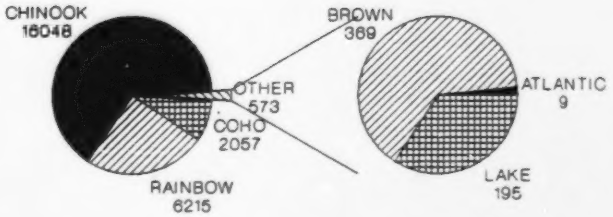


FIG. 2. The species composition of the harvest from Lake Ontario by launch daily anglers in each district during 1989. Unknown salmonids are not included here (see Table 9).

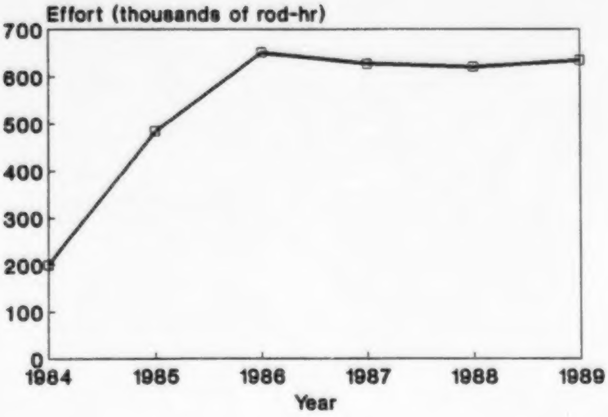


FIG. 3. Effort by launch daily anglers in the Central Region in Lake Ontario.

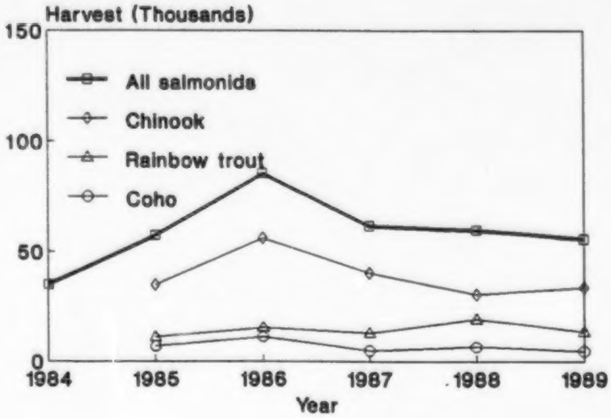


FIG. 4. Harvest by launch daily anglers in the Central Region in Lake Ontario.

moored boats is similar to the effort of launch daily anglers, but the harvest (108,987 salmonids) by charter boats and moored boats exceeds the total for the launch daily anglers.

Another unique aspect of the Napanee District fishery is that the largest proportion of the charter boat operators are unaffiliated. This makes monitoring of this component difficult, but we suspect it is symptomatic of a developing fishery.

From 1986 to 1989, fishing effort of launch daily anglers in the Central Region was relatively constant (Fig. 3). Total salmonid harvest peaked in 1986, but has remained relatively constant from 1987 to 1989 (Fig. 4). The decline in chinook harvest observed from 1986 to 1988 did not continue into 1989 but total harvest was offset by a slight decline in rainbow trout harvest. Trends in the Toronto Star Derby CUE show a continuing decline in overall salmonid catch rates, largely due to decreases in rainbow trout and coho (Fig. 5). Until independent sampling programs to measure salmonid relative abundance and angling selectivity are implemented, these changes are difficult to interpret.

Moored boat activity in Napanee District was likely minimal due to the lack of marina facilities, resulting in a conservative total effort estimate of 105,243 rod-hr. This represents an increase from 48,785 rod-hr estimated in 1987 for both charter and unguided boat anglers (Mathers 1988). While methods differed between the 1987 and 1989 surveys we interpret these findings as representing a major growth in the Napanee District salmon fishery. Furthermore, comparing these results to the Central Region estimates (Table 7), one must conclude that the salmon fishery is of comparable magnitude in all districts of Lake Ontario.

The charter boat fishery in Kingston basin of Napanee District was estimated to be 1.4 times greater in effort than the central and western basin portions of Napanee District, based on the charter boat survey for 1989. Therefore, the Kingston Basin fishery has also continued to grow since the last survey by Mathers (1988).

The species mix of the harvest varied by fishery component (Table 9). On a relative basis, moored boat anglers showed little species preference and generally caught fish in proportion to the total catch by all angling groups (Table 9). Charter boats in the Central Region showed greater preference for rainbow trout and decreased preference for most other species except coho. Charter boat and launch daily anglers in Napanee District showed as strong preference for chinook and lake trout. The launch daily anglers in Central Region had a slight preference for chinook. The regional differences in relative preference might reflect differences in fish species distribution rather than angler selectivity, but the differences within a region likely reflects selectivity by the different angling groups.

The remaining components of the salmonid fishery are the shore fishery and the Kingston Basin Fishery. A summer shore survey was completed in Niagara District in 1988 and

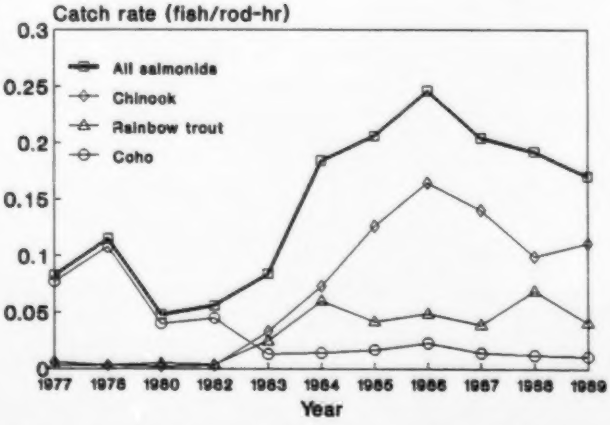


FIG. 5. CUE by launch daily anglers at selected access points in Lake Ontario during the Toronto Star Derby. Only Port Credit and Bluffer's Park access points were

Table 9. Summary of harvest by species and fishery component.

Species	Launch daily				Charters				Moored		Total	
	Central Region		Napanee District		Central Region		Napanee District					
Coho	4,552	(8.2)	304	(3.4)	6,770	(10.0)	219	(4.3)	3,722	(10.3)	15,567	(9.0)
Chinook	33,600	(60.3)	5,960	(67.1)	33,238	(49.0)	3,721	(73.0)	19,851	(55.0)	96,370	(55.5)
Rainbow trout	13,391	(24.0)	1,467	(16.5)	27,193	(40.1)	606	(11.9)	11,476	(31.8)	54,133	(31.2)
Brown trout	985	(1.8)	199	(2.2)	247	(0.4)	94	(1.8)	620	(1.7)	2,145	(1.2)
Atlantic salmon	248	(0.4)	0	(0.0)	96	(0.1)	71	(1.4)	93	(0.3)	508	(0.3)
Lake trout	1,928	(3.5)	956	(10.8)	274	(0.4)	386	(7.6)	310	(0.9)	3,854	(2.2)
Unknown salmon	1,011	(1.8)	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)	1,011	(0.6)
Total	55,715		8,886		67,818		5,097		36,072		173,588	

Table 10. Mean length and weight of salmonids harvested in the angling fishery of Lake Ontario during 1989. Central Region means were weighted by harvest.

Species	Central Region			Napanee District		
	N	Fork Length (cm)	Weight (kg)	N	Fork length (cm)	Weight (kg)
Coho	324	58.80	3.19	44	61.52	3.58
Chinook	1330	68.44	5.62	767	65.65	5.02
Rainbow trout	633	62.20	3.08	175	60.92	2.99
Brown trout	84	54.25	2.64	23	47.47	2.24
Atlantic salmon	11	47.65	1.16	2	50.5	1.6
Lake trout	106	59.89	2.97	91	60.89	3.64

when the results are available this should provide some insights into the magnitude of this component.

Biological Characteristics of Harvested Fish

The size of salmonids in the harvest was similar in the Central Region and Napanee District (Table 10). Slight differences are more likely due to differences in angler preference and in age composition of the harvest than differences in growth.

Fin clips show that a minority of coho, rainbow trout, and brown trout in the fishery originated from OMNR stockings (Table 11). The majority of these species in the harvest were unclipped, and therefore were naturally produced or originated from American stockings. A proportion of rainbow trout attributed to Canadian stockings in the Central Region has increased from 22 - 37% in 1987 (Stewart 1988), 4.4% in 1988 (Stewart and Savoie, 1989) to 8.5% in 1989 (Table 11). This may be due to recent increases in stocking rates (Savoie and Letendre, 1989) and replacement of domestic strains of rainbow trout with exclusive stocking of wild Ganaraska River strain beginning in 1984. The fin clip distribution in Napanee District was similar to Central Region (Tables 11).

Table 11. Fin clip summary for salmonids observed in the angler survey in Lake Ontario during 1989. The percentages are calculated from estimated numbers that were weighted by harvest.

Clip origin	Coho	Rainbow trout	Brown trout
Central Region			
New York clip	0.0%	27.4%	7.8%
Ontario clip	25.7%	8.5%	45.6%
Other clips	3.2%	0.6%	2.8%
Unclipped	71.1%	63.3%	43.7%
Total number	324	635	85
Napanee District			
New York clip	0.0%	20.6%	8.7%
Ontario clip	13.7%	7.4%	21.6%
Other clips	2.3%	0.0%	0.0%
Unclipped	84.1%	72.0%	69.6%
Total number	44	175	23

Table 12. Observed harvest of adult coho stocked as fall fingerlings or spring yearlings in Ontario tributaries of Lake Ontario. Expected proportions were determined from stocking densities.

Stocking period	Clips	Observed frequency	Observed proportion	Expected proportion
Fall 1987	RV & Ad	48	0.6400	0.6161
Spring 1988	RVAd	27	0.3600	0.3839

A slightly higher proportion of unclipped fish in Napanee District is consistent with the high number of quality salmonid nursery streams in Napanee and Lindsay Districts. The year class of adult coho harvested this year originated from from a fall 1987 stocking of fingerlings clipped RVAd, and spring 1988 plantings in the Credit River (clipped Ad), Bronte Creek (clipped RV), and Port Dalhousie (clipped RV). There was no difference between the observed and expected harvest of the spring and fall stocked coho (G = 0.09, P > 0.05; Table 12). Accordingly, survival of this year class was similar between spring and fall stocking.

Plante and Bowlby (1990) found that survival of spring stocked fish in the Credit was higher than fall stocked fish. Thus, survival of fall stocked coho must have been greater at Bronte Creek or Port Dalhousie.

Recently OMNR initiated an experimental Atlantic salmon stocking program. The first angler catches of these Atlantic salmon in Lake Ontario were made in 1989. Length, weight, and fin clips of 14 Atlantic salmon observed in the survey have been presented in Table 13. One fish was thought to originate from the 1988 Canadian stocking in Wilmot Creek (RV clip). One fish was unclipped and the remaining were stocked by New York State. Fish stocked in the Credit River in 1988 (AdRv) were not observed in the sample.

Table 13. Atlantic salmon sampled during the angler survey in Lake Ontario during 1989. Clip codes are RV - right pelvic, LV - left pelvic, Ad - adipose, and LP - left pectoral. Percent regeneration of a clipped fin is indicated in parenthesis

District	Clip	Fork Length (cm)	Weight (grams)
Niagara	RV(0)LV(0)	51	1,800
Cambridge	RV(10)	43	800
Cambridge	RV(0)LV(0)	46	900
Maple	Ad(0)	90	11,250
Maple	Ad(0)	46	1,000
Maple	Ad(0)	46	1,000
Maple	RV(0)LV(0)	56	1,600
Maple	Ad(0)	-	-
Lindsay	Ad(0)	49	1,000
Lindsay	Ad(0)	48	1,200
Lindsay	RV(0)LV(0)	48	1,500
Lindsay	RV(0)LV(0)	49	1,000
Napanee	-	43	1,200
Napanee	LP(50)LV(0)	58	2,000

Acknowledgments

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A Model to Relate CREESYS Estimated Fishing Effort to Trailer Counts at Launch Ramps in the Lake Ontario Salmonid Fishery

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Lake Ontario Fisheries Unit, 1989 Annual Report, LOA 90.1 (Chapter 13)

The salmonid fishery in the western basin of Lake Ontario has been monitored since 1977 with a steadily increasing level of fishing effort being expended. By 1988 approximately 50% of the launch daily angling effort was being surveyed and trailer counts were being done at all public access points on the weekends. The trailer counts have been used in the past to prorate the survey effort estimates to the whole fishery. This was based on the assumption that there is a linear relationship between the trailer counts and fishing effort as estimated by the survey. If true, it should be possible to reduce the intensity and duration of sampling and use the trailer counts to generate basin wide effort estimates of acceptable precision that are more economical. A model is developed using data from the 1987, 1988 and 1989 surveys that allows us to generate basin wide effort estimates within each year. The nature of the relationship is not constant across years. Further work should be undertaken to expand and refine the applicability of this approach.

Recommendations

1. Reduce creel survey intensity to lowest level that will still provide adequate precision and use trailer counts and model to prorate to basin wide estimates.
2. Expand trailer count program to weekdays.
3. Continue to develop the model especially with regards to weekend and weekday differences and the use of non-linear and/or polynomial approaches to improve the fit at higher effort levels.
4. Investigate alternative measures to trailer counts such as automated traffic counters at launch ramps

Introduction

The salmonid fishery in the western basin of Lake Ontario has been monitored since 1977 with a steadily increasing level of fishing effort being expended. By 1988, approximately 50% of the launch daily angling effort was directly surveyed (Stewart and Savoie 1989). With increasing fishing effort the costs of monitoring have escalated.

The monitoring program consists of daily trailer counts at all public access points on the weekends and access creel surveys (on both weekends and weekdays) at selected points chosen to maximize the proportion of the total effort monitored. In the early years, the selected sites were monitored only during fishing derbies but recently the expanding fishery has necessitated increasing the scope of monitoring. In 1987, sites were monitored continuously during the fishing season from April through September, requiring an intensive and expensive sampling program.

The creel survey data has been collected and analysed using the OMNR CREESYS (Lester and Trippel 1985) creel design and analysis system which is based on a two stage cluster sampling model and reports estimates of effort, catch, harvest and catch-per-unit-effort (CUE).

The trailer counts have been used in the past to prorate the creel effort estimates to the whole fishery. This was based on the assumption that there is a linear relationship between the trailer counts and fishing effort as estimated by the survey. Although this assumption was tested for 1987 (Stewart 1988), the nature of the relationship and its year-to-year variability have not been investigated.

If the relationship is very strong then it should be possible to reduce the intensity and duration of sampling and use the trailer counts to generate basin wide effort estimates of acceptable precision that are more economical. For example, a creel survey of one site on one day requires 8 man-hours of labour. If an appropriate model can be developed, the same amount of labour would provide effort estimates for all 28 launch sites from Niagara-on-the-Lake to Cobourg.

What, however, is the nature of the relationship between trailer counts in a parking lot and fishing effort in the lake? Fishing effort can be seen as a product of three variables: the number of fishing boats on the water, the number of anglers in each of those boats and the amount of time each angling party spends fishing. The trailer count supplies an index of the number of boats and the mathematical relation between it and the CREESYS effort estimate incorporates estimates of number of anglers and trip duration. If any relation is to be valid, the number of anglers and the trip duration must be either constant or at least be random.

There are several factors which could effect the relationship between fishing effort and trailer counts. The most obvious perhaps is the fact that not everyone who takes a boat out on Lake Ontario is going fishing. After all, as Kenneth Grahame has said: "There is nothing - absolutely nothing - half so much worth doing as simply messing about in boats" (Grahame 1908). This then, must be taken into account in any model, and data on the number of non-fishing boats using the launch ramps is routinely collected with the creel survey.

The other major effects which must be considered are temporal and spatial differences. It may be, for instance, that certain launch ramps are more heavily used by 'serious' fishermen than by casual fishermen and this would result in differing numbers of anglers per boat and differing trip lengths for some sites. If this is the case then a model is not going to be useful because it would require that a different relationship be developed for each launch site and that would be impractical. Seasonal differences may also exist. While this would have to be incorporated into the model, data is already being collected over the entire fishing season so it would present no great difficulty. There may also be a difference between weekends and weekdays. Although trailer count data has not been collected on weekdays previously, a special effort was made in 1989 to collect this data for the creeled sites in order to test this difference.

This project was set up to determine the nature of the relationship between boating activity (as measured by trailer counts) and fishing effort (as estimated by CREESYS), to develop a model of that relationship to be used for estimating Lake Ontario fishing effort in 1989 and to provide a tool for improving the design, efficiency and economy of future surveys.

Methods

Details of the creel survey designs for 1987, 1988 and 1989 can be found in Stewart 1988; Stewart and Savoie 1989; Stewart et al. 1990.

The model was developed using the GLM Procedure of the SAS Statistical Analysis System. The notation follows that of SAS. Classification (independent) variables are designated A,B,C..., continuous regressor (independent) covariates are designated X1, X2... and response (dependent) variables are designated Y1, Y2...

Three separate data sets from 1987, 1988 and 1989 are available for the development and testing of the model. The creel and trailer count data from 1987 were used to develop a model which was then tested against the data for 1988. Similarly, the 1988 data were used to develop a model independently of 1987 which was then tested against the 1987 data. If the two models are considered to be sufficiently alike, the data from both years can be combined to generate a model which should illuminate any year-to-year differences that exist and may allow us to predict fishing effort in subsequent years. This model would then be tested against 1989 data.

The 1987 data set (Fig. 1) consists of the CREESYS daily effort estimates for the weekend and holiday days at five sites around the western basin together with data on the number of non-fishing boats using the launch ramp on the days of the survey. To this is added the trailer counts at those five sites on the days of the survey. The 1988 data set (Fig. 2) is similar except that six sites were surveyed. The 1989 data set (Fig. 3)is quite different in that 4 sites were surveyed, two of which were surveyed in April and May while the other two were surveyed from June through September. Trailer count data were collected on weekdays as well as weekends from June through September.

The model development process started with a full range of independent variable which were expected to explain nearly all variation in the dependent variable Y1 (see Table 1 for variable identifiers). In order to do this, all of the measured variables that can be reasonably expected to have an effect must be included in the model. The first of these and the one of prime interest is the trailer COUNT (X1).

Table 1. Variable Identifiers

Variable	ID	Description
EFFEST	Y1	Daily estimated effort from CREESYS at given site
COUNT	X1	Trailer count at given site
PNFB	X2	Proportionate non-fishing boats
MO	A	Month (April = 1, September = 6)
SITE	B	Access point for boat launching
YEAR	C	
TYPE	D	Daytype (Weekend or Weekday)

The second continuous effect (X2) of importance is related to non-fishing boats. It cannot simply be the total daily count of non-fishing boats because the trailer count is not a total count but rather an index, a point-in-time count taken randomly between 10:00 am and 2:00 pm. The variable used is the proportion of non-fishing boats (PNFB) which is calculated as:

$$\frac{\text{non-fishing boats}}{\text{non-fishing boats} + \text{fishing boats} + 0.5}$$

The 0.5 is a correction factor to prevent division by zero in the computer calculations.

The data can also be sorted based on three classification criteria, season or month MO (A), SITE or launch ramp (B) and, for the combined model, year (C).

Interactions between the effects must also be taken into account and are of two forms; those which affect the intercept of the model (A*B) and those which affect the slope (X1*A, X1*B, X1*C, X2*A, X2*B, X2*C). The full model that we start with is:

$$Y1 = X1\ X2\ A\ B\ X1{*}A\ X1{*}B\ X2{*}A\ X2{*}B\ A{*}B$$

Results - 1987

As expected, the fully specified model (Table 2) explains 99.8% of the variation in the CREESYS effort estimates so we can be confident that we have included all relevant factors. However, the model as it stands is unusable because it is overspecified and we must analyse the results to see what effects can be removed without unduly reducing its explanatory power.

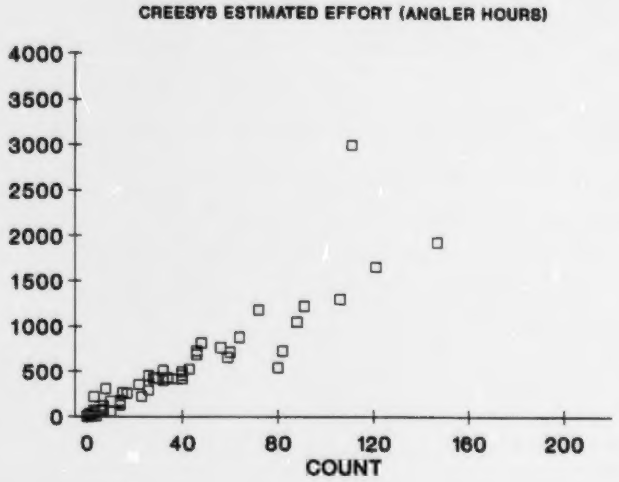

FIG. 1. Scatter plot showing the relationship between trailer counts and estimated fishing effort in 1987.

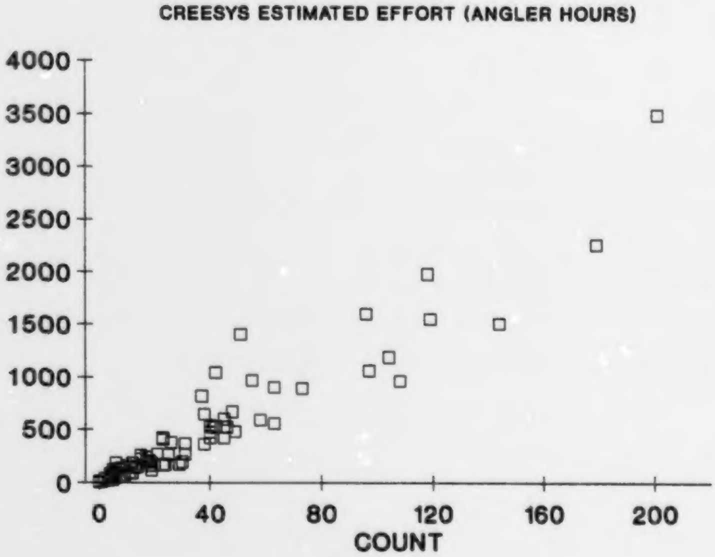

FIG. 2. Scatter plot showing the relationship between trailer counts and estimated fishing effort in 1988.

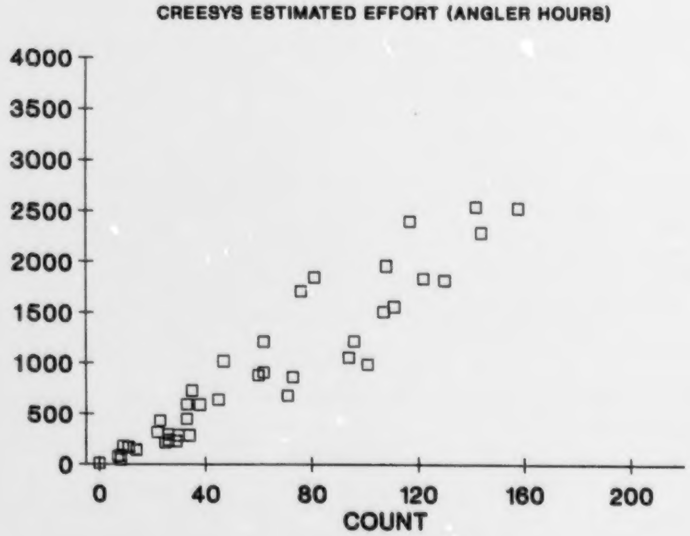

FIG. 3. Scatter plot showing the relationship between trailer counts and estimated fishing effort in 1989.

Table 2: Summary of models for 1987

		Significance level associated with effect								
R-Square	C.V.	COUNT	PNFB	MO	SITE	COUNT*MO	COUNT*SITE	PNFB*MO	PNFB*SITE	MO*SITE
Full model for 1987 (Y1 = X1 X2 A B X1*A X1*B X2*A X2*B A*B)										
0.9988	11.9675	0.0001	0.0028	0.0727	0.2264	0.0420	0.0504	0.3418	0.0239	0.1671
MODEL: Y1 = X1 X2 X1*A X1*B X2*B (1987)										
0.96478	22.1002	0.0001	0.0011			0.0243	0.3018		0.8770	
MODEL: Y1 = X1 X2 X1*A (1987)										
0.9588	21.6656	0.0001	0.0007			0.0181				

From the Type I sums of squares (Freund and Littell 1981) it can be seen that there is no main effect on the intercept due to either MO or SITE or the MO*SITE interaction (Table 2). Nor is there a significant effect of MO on the PNFB component of the slope. The next step is to drop all the non-significant effects and re-run the model.

The reduced model has lower explanatory power (Table 2) but is still very good. From the Type I sums of squares it can be seen that there is no difference in the slope of the relationship at different sites and that these interaction terms can be dropped for a third run.

The model which contains only the count and PNFB variables together with an interaction factor changing the slope based on MO still provides a explanatory ability of 96% and has few enough variables to be practical (Table 2). All of the included variables are significant. An examination of the residual plot (Fig. 4) reveals no patterns to indicate an innappropriate model.

To verify the model we must predict 1988 effort estimates using the trailer count and PNFB data from 1988 and the relationship specified by the model parameters:

$$\text{EFFEST} = B_0 + (B_1 + B_3)*\text{COUNT} + B_2 * \text{PNFB}$$

where B_0 is the INTERCEPT estimate, B_1 is the COUNT (slope) estimate, B_3 is COUNT*MO interaction estimate and B_2 is the PNFB (covariate slope) estimate (Table 3). The predicted effort estimate (TCEFF) is then regressed against the actual effort for 1988. The r^2 should be high and the slope of the regression (when forced through the origin should be 1). That is, the predicted effort should be the same as the measured effort. Although the r^2 is quite high (Table 4), the slope of the relation is significantly less than 1 so that this model underestimates 1988 effort and the degree of underestimation increases as effort increases.

Results - 1988

The 1988 model was developed the same way. The full model explains 96% of the variation in effort and is overspecified (Table 5). There are only three significant factors based on the Type I sums of squares and these are COUNT PNFB and COUNT*MO so the second run of the model is of the same form as the final 1987 model.

The final 1988 model (Table 5) explains 91.4% of the variation in effort which is not quite as good as the 1987 model but still acceptable and the residual plot (Fig. 5) is normal. The parameter estimates for the model are shown in Table 6.

Table 3: Model Parameter Estimates for final 1987 model (Y1 = X1 X2 X1*A)

Parameter		Estimate	Standard Error
INTERCEPT		97.5488103	33.34537189
COUNT		11.5937746 B	0.87995382
PNFB		-165.7409672	62.79465011
COUNT*MO	1	1.2501142 B	1.00730909
	2	-2.0049995 B	1.19848269
	3	2.3651021 B	1.22070301
	4	-0.3389321 B	0.96578692
	5	0.3270497 B	1.00395109
	6	0.0000000 B	

The test of the model, the prediction of 1987 effort from the 1988 model, worked (Table 4) because the slope is effectively 1. This is, therefore, the preferable model and the next step is to test it against the 1989 data (Table 4). The model does not work as a predictor of 1989 effort because the slope is significantly less than 1.

Although neither model works as a predictor, the fact that both models have the same form and that the r^2 values are high in the prediction regressions implies a common relationship and justifies combining the two data sets (1987, 1988) to generate another model. In this case, however, we have to include an additional variable YR and because of the prediction results the interaction of COUNT*YR and PNFB*YR must be examined.

Results - Combined Model

The combined model has the form:

Y1 = X1 X2 C A B X1*C X1*A X1*B X2*C X2*A X2*B A*B

The results of the full model are shown in Table 7. the only factors that are significant are the regressor variables COUNT and PNFB and the COUNT*YR interaction which was expected based on the tests of the 1987 and 1988 models.

The model was re-run, dropping all the non-significant effects and the results are shown in Table 7. In the reduced model, the COUNT*YR interaction is no longer significant and can be dropped.

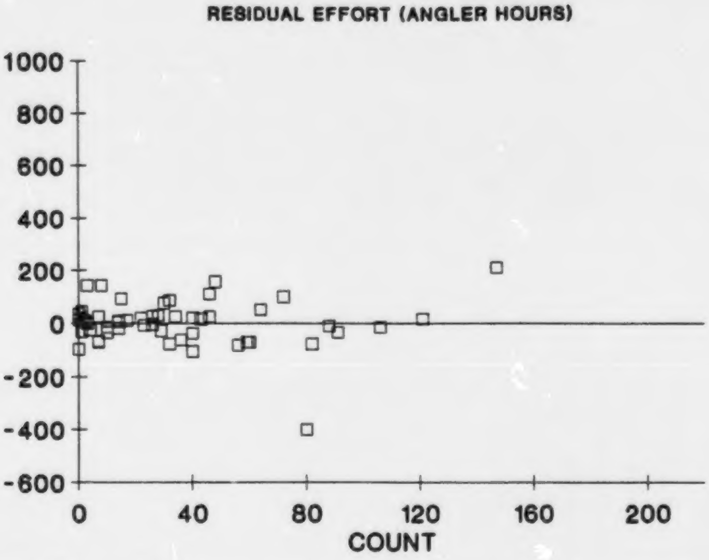

FIG. 4. Plot of residuals from the final 1987 model as described in Table 3.

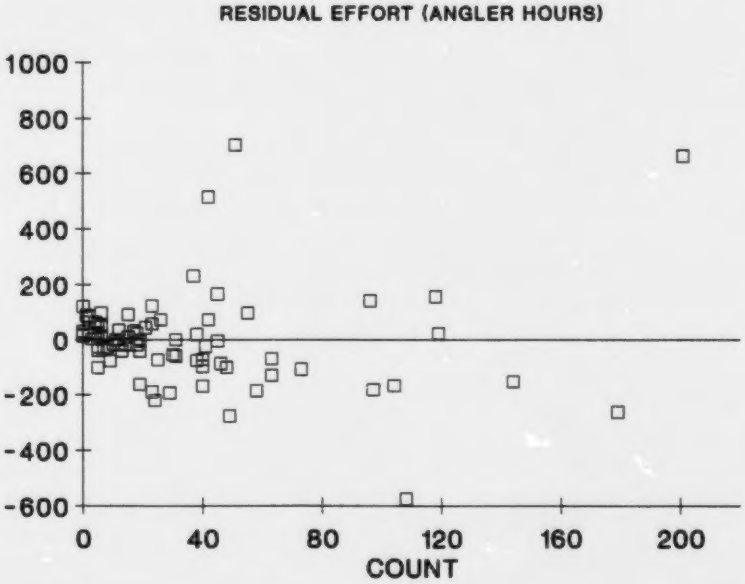

FIG. 5. Plot of residuals from the final 1988 model as described in Table 6.

Table 4: Regression of predicted effort versus actual effort for models (NOTE: No intercept in model. R-square is redefined). The Prob. Slope = 1 is the probability of exceeding the T value calculated for the Ho: Slope = 1.

Model Data set	Data set Predicted	R-square	Adj. R-sq	C.V.	Slope	St. Error	Prob. Slope=1
1987	1988	0.9100	0.9088	42.73590	0.800298	0.02886740	< 0.001
1988	1987	0.9450	0.9440	33.97885	0.987666	0.03302728	0.75
	1989	0.9476	0.9463	29.56409	0.813179	0.02986718	< 0.001
87/88	1987	0.9728	0.9723	23.53064	1.015023	0.02354639	0.70
	1988	0.9384	0.9376	37.97143	0.916344	0.02692877	0.002
	1989	0.9604	0.9594	25.32172	0.819713	0.02600844	< 0.001
1989 (WE)	1989 (WD)	0.9711	0.9700	24.27653	1.052177	0.03560450	0.17
1989 (WE/WD)	1989 (WD)	0.9815	0.9808	19.80983	0.988611	0.02662841	0.65
	1989 (WE)	0.9625	0.9616	25.17326	0.949890	0.02926693	0.09

Table 5: Summary of models for 1988

		Significance level associated with effect								
R-Square	C.V.	COUNT	PNFB	MO	SITE	COUNT*MO	COUNT*SITE	PNFB*MO	PNFB*SITE	MO*SITE
Full model for 1988 (Y1 = X1 X2 A B X1*A X1*B X2*A X2*B A*B)										
0.96173	41.1854	0.0001	0.0834	0.7396	0.7720	0.9119	0.0579	0.5632	0.6623	0.3230
MODEL: Y1 = X1 X2 X1*A (1988)										
0.91431	39.2570	0.0001	0.0638			0.0476				

Table 6: Model Parameter Estimates for final 1988 model (Y1 = X1 X2 X1*A)

Parameter		Estimate	Standard Error
INTERCEPT		74.3622482	53.69108062
COUNT		10.0681786 B	1.89140311
PNFB		-215.8865728	114.14655985
COUNT*MO	1	0.9596635 B	2.13252215
	2	3.6727511 B	1.88710591
	3	2.0239369 B	3.09903318
	4	4.8750307 B	1.93369050
	5	2.5595637 B	1.95581023
	6	0.0000000 B	

Table 7: Summary of models for combined 1987/1988 data

		Significance level associated with effect											
R-Square	C.V.	COUNT	PNFB	MO	SITE	YR	CNT*YR	CNT*MO	CNT*SITE	PNFB*YR	PNFB*MO	PNFB*SITE	MO*SITE
Full model for 1987/1988 (Y1 = X1 X2 C A B X1*C X1*A X1*B X2*C X2*A X2*B A*B)													
0.94923	35.6923	0.0001	0.0050	0.7777	0.8751	0.9906	0.0329	0.3228	0.8968	0.8691	0.9017	0.1987	0.1759
MODEL: YI = X1 X2 X1*C (combined data 87/88)													
0.91048	35.5762	0.0001	0.0043				0.1296						
MODEL: YI = X1 X2 (Combined 87/88 data)													
0.90883	35.7617	0.0001	0.0045										

The final combined model (Table 7) is a simple one with only the two regressor variables of COUNT and PNFB being significant. The r^2 for this model is lower than for either of the years independently but, at 91% is still quite good. The residual plot shows a tendency to increased spread as COUNT increases (Fig. 6). This implies heterogeneity of variance in which case transformation of the data may be necessary. This was done using both the logarithmic and square root transformations but this had no effect on the residuals or on the tests of the model discussed in the next paragraph.

The parameter estimates for the combined 1987/1988 model are shown in Table 8.

Table 8: Model Parameter Estimates for final 1987/1988 model (Y1 = X1 X2)

Parameter	Estimate	Standard Error
INTERCEPT	75.4671120	34.93874552
COUNT	12.9011814	0.41414548
PNFB	-206.8107769	71.49218430

Because this combined model is different in form from the 1987 and 1988 models from which it is derived, testing the model has three components. The first two involve comparing predicted against actual effort for each of 1987 and 1988 to determine if this is a 'compromise that pleases no one' or an appropriate model. The results of these comparisons are shown in Table 4. The model is very good as a predictor of 1987 but not 1988 for although the r^2 is high the slope is significantly different from 1. The third component of the test is the comparison of predicted versus actual effort for 1989 (Table 4). Here too, the explanatory power is high but the slope is significantly less than 1.

Results - 1989

If we cannot predict across years then we must develop the model independently within each year and that means a separate model for 1989. Also in 1989 we have trailer count data for some weekday creels and this allows a comparison of the two day-types.

The results for the full model (weekend) are shown in Table 9. As was the case for the other years, most of the effects are not significant and the full model explains a large proportion of the variability.

The second run of the 1989 model (Table 9) is of the same form as the combined 87/88 model and has about the same explanatory power. The residual plot shows a trend towards heterogeneity of variance (Fig. 7) but standard transformations do not help. The parameter estimates are shown in Table 10.

Table 10: Model Parameter Estimates for 1989 (WEEKEND) model (Y1 = X1 X2)

Parameter	Estimate	Standard Error
INTERCEPT	141.0862592	93.3026268
COUNT	15.1682341	0.8847625
PNFB	-563.1635472	203.0169849

The ability of the 1989 weekend model to predict weekday effort is very high (Table 4) with an r^2 of 97% and a slope of 1.05 which is not significantly different than 1.

A combined model based on the final 1989 model and adding daytype (TYPE) as a class variable as well as COUNT*TYPE and PNFB*TYPE interactions (Table 11) shows as well that neither TYPE nor its interaction effects are important.

The removal of those effects leaves the last model (Table 11) which has the same form as the weekend model and similar properties and parameter estimates (Table 12). The tests of this model against the weekday and the weekend data (Table 4) are both positive with high r2 and slopes close to 1.

Overall, the model developed from just the weekend data is preferable because it has a lower coefficient of variation than the model based on combined data (Tables 9 and 11) and the greater heterogeneity of variance associated with the combined model (Fig. 8) makes findings of non-significance with a high p value dubious.

Discussion

The model development process has allowed us to reach several conclusions about the nature of the salmonid fishery in Lake Ontario. However, this discussion only applies to the launch daily fishing effort and not to the marina based and charter fisheries which may have different characteristics.

Table 9: Summary of models for 1989 (WEEKEND)

		Significance level associated with effect								
R-Square	C.V.	COUNT	PNFB	MO	SITE	COUNT*MO	COUNT*SITE	PNFB*MO	PNFB*SITE	MO*SITE
Full Model 1989 (Y1 = X1 X2 A B X1*A X1*B X2*A X2*B A*B)										
0.965653	25.76373	0.0001	0.0127	0.9653	0.4350	0.3650	0.9843	0.2205	0.8016	0.1028
MODEL: Y1 = X1 X2 (1989)										
0.914459	26.04228	0.0001	0.0085							

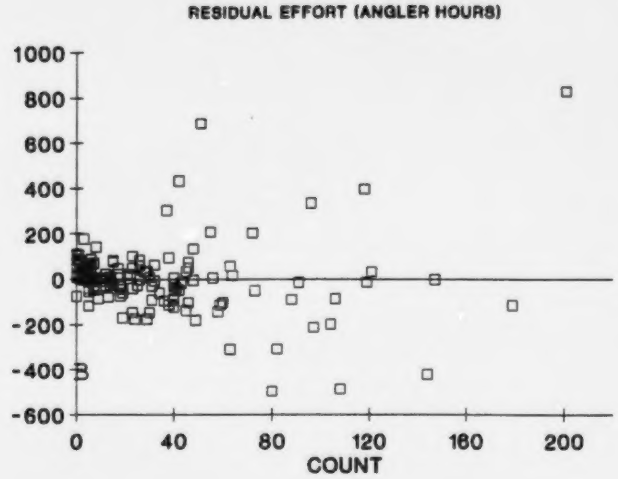

FIG. 6. Plot of residuals from the combined 1987 and 1988 model as described in Table 8.

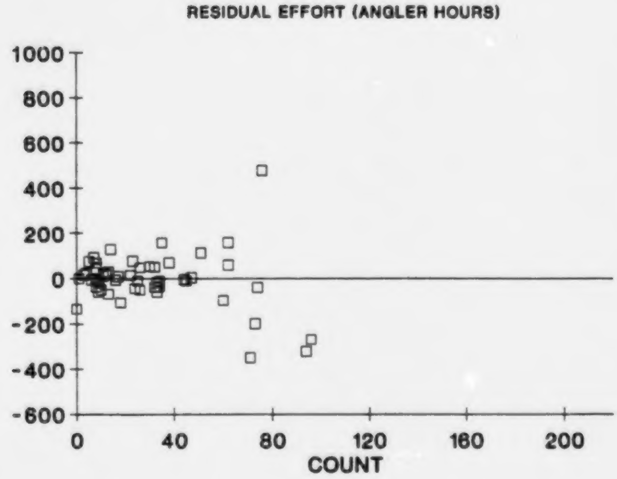

FIG. 7. Plot of residuals from the weekend only 1989 model as described in Table 10.

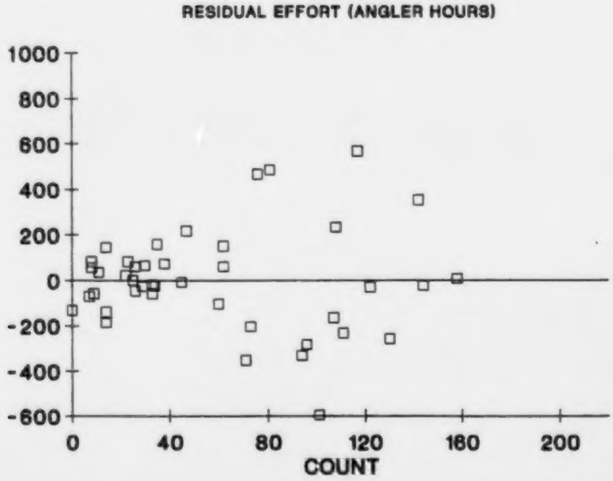

FIG. 8. Plot of residuals from the combined weekend and weekday 1989 model as described in Table 12.

Table 11: Summary of models for 1989 (combined WEEKEND & WEEKDAY)

		Significance level associated with effect				
R-Square	C.V.	COUNT	PNFB	TYPE	COUNT*TYPE	PNFB*TYPE
Full Model 1989 combined Weekend & Weekday (Y1 = X1 X2 D X1*D X2*D)						
0.92378	0.5947	0.0001	0.0096	0.9049	0.9764	0.0996
MODEL: Y1 = X1 X2 (1989 Combined weekend and weekday data)						
0.91983	0.5471	0.0001	0.0094			

Table 12: Model Parameter Estimates for 1989 (combined WEEKEND and WEEKDAY) model (Y1 = X1 X2)

Parameter	Estimate	Standard Error
INTERCEPT	68.7645347	51.3527282
COUNT	15.3082991	0.6451133
PNFB	-331.7951221	123.3951258

The site of boat launch is not an important consideration in terms of the relationship between trailer counts and fishing effort. Any differences in effort among sites are a function of the differences in number of boats being launched and not differences in the nature of the fishing effort (number and type of angler and trip length) among launch sites. This confirms the assumption that past analyses have used.

Season does appear to be important. While there were no differences in the mean levels (intercept) of effort among seasons, the nature of the relationship (slope) between trailer counts and effort was different for each season in the 1987 and 1988 data sets. That this pattern was not evident in the 1989 dataset may be due to the smaller size of that data set or to the fact that the survey sites were only sampled during the derby periods when counts and efforts were high. Since the residual plots for 1989 (Fig 7 and 8) show heterogeneity of variance, the high variances associated with higher count and effort may be sufficient to mask real differences in a small data set.

There are also important differences among years in the nature of the relationship (Fig. 9; Tables 3, 6, 10). The differences were confirmed by running an analysis of variance followed by Duncan's multiple range test on the individual trip lengths for the three years. Significant differences exist among all three years. This is to be expected since the number of fishing trips, number of anglers and length of fishing trip can all be expected to vary with changing economic and social conditions as well as with real and perceived changes in the fishery.

The final effect which might be expected to be important is day-type. There may be a difference in the nature of the fishing effort between weekdays, when only dedicated, serious fishermen would be out on the water and weekends when there would also be large numbers of casual fishermen. This difference might also be expected to change through the seasons being stronger in the spring and fall when weather would deter casual fishermen and when fewer people have holidays. The analysis of the 1989 data (Tables 9 - 12) failed to detect such a difference but, for the reasons stated above regarding seasonal differences, this result should be treated cautiously.

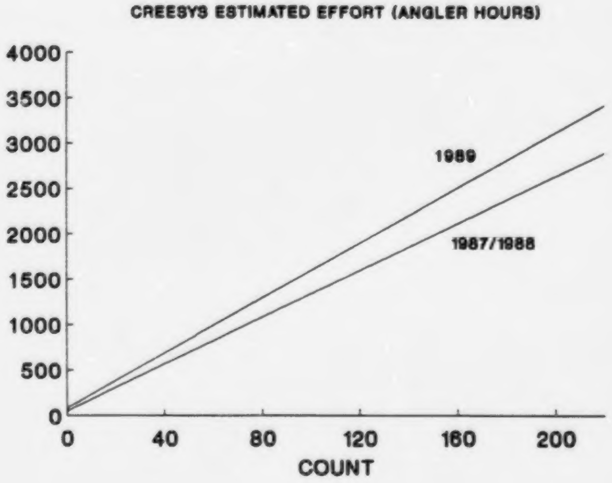

FIG. 9. Comparison of the final 1989 (Table 10) and combined 1987/88 (Table 8) with PNFB set = 0.1.

For future surveys it will be necessary to collect concurrent trailer count and fishing effort data to develop a predictive model for each year. Weekday and weekend days should be modelled and surveyed independently. Predictive power of these models is expected to be high and with proper design, the cost of surveys can be reduced.

The major problem with the models as presented is the presence of heterogeneity of variance which is shown in some of the residual plots. This would mean less confidence in predictions associated with high trailer counts and efforts. This is not a great problem because the creel surveys are concentrated in the areas and times of greatest effort so we have independent estimates for these situations. It does, however, indicate that a more appropriate relationship might be found through transformation of the data or the use of non-linear or polynomial regression. Some standard transformations (logarithmic and square root) have been tried but they did not help and any further transformations should be based on a thorough analysis of the distributions of the data.

It is also possible that trailer counts taken at a single time of the day may not be the best indicator of boating activity, especially on busy days and attention should be given to identifying alternate measures of boat activity. Automated traffic counters at the launch ramps and activity counts from pay for launch sites are two possibilities.

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Research Project: Fish Community Dynamics Of The Outlet Basin Of Lake Ontario

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Lake Ontario Fisheries Unit 1989 Annual Report, LOA 90.1 (Chapter 14)

Background and Objectives

For the past 28 years, fish sampling at the community level has been conducted each summer in the Outlet Basin of Lake Ontario. This long-term index series has been conducted in a very consistent and standard fashion. Six fixed deep-water stations (26-38 m) have been sampled once a month during the summer (May to August) with multifilament experimental gillnets ranging in mesh size from 1.5 to 6 inches and since 1972, with a 3/4 "Yankee Standard" No. 35 bottom trawl. Although the stations and gillnets were originally designed to assess change in the whitefish population, they have become a long-term, standard "lake" index series for fisheries research.

More recently, this sampling has been used to study and document the response of the fish community to the re-introduction of the once-abundant, large, piscivorous lake trout. It also has provided the opportunity to assess the effects of changes in water quality on the fish community of the Outlet Basin and the adjacent waters of the Bay of Quinte. Special emphasis has been placed on such species as lake trout, lake whitefish, lake herring, smelt, and alewife. Detailed studies of community dynamics and species interaction are planned.

Progress

Since usually only one sample was drawn per station per month, there was no measure of observational variability for the sampling methodology and the community involved in this long-term series. In 1988, a study of sampling variability was initiated. In addition to routine sampling, monofilament gillnets were fished concurrently with the multifilament nets at each station. In 1989, in addition to the standard effort, three more 25-yd panels of each of 1.5- and 2-inch mesh nets was used. This meant that a total of 100 yards of each mesh size was fished. In 1989, all meshes were subsampled by 50-ft intervals, providing a total of six replicate catches to measure the observational variability associated with these large units of gillnet effort. The results of this study will be reported in a subsequent project.

Trawling was not conducted in 1989 because the research vessel used for this work was away for the year being completely refitted at a shipyard on Lake Erie. Trawl catches were estimated for 1989 by using a correlation that exists between trawl catches of smelt and alewife and catches of the larger individuals of these species entangled in the large mesh of the experimental gillnets. These correlations are significant at the 5-% and 8% levels respectively.

Changes in relative abundance of the catches are illustrated for the gillnets (Fig. 1) and for the bottom trawls (estimated for 1989) (Fig. 2). Some general trends are apparent in this intensive sampling series and are presented independent of any measure of sampling variability, which will be presented and discussed later. In 1989, catches of lake trout in July in 4.5-inch mesh were the highest ever recorded in this series (Fig. 1A). Lake trout catches in the Outlet Basin indicate a continued buildup in the size of the introduced lake trout population. Lake trout catches in late summer in the Outlet Basin probably underestimated the size of the populations, since for the second consecutive summer, the thermocline reached the bottom in most of the basin in August. This no doubt affected the distribution and abundance of lake trout in the catch. Catches at the various stations in August 1989, as in the previous year, indicated that during the past two summers, which were extremely warm, lake trout moved out of the Outlet Basin and into the deeper, cooler main basin of the lake during late summer. The lake whitefish catches were similar to the previous year but were the highest recorded for the past 28-year of sampling. Lake herring catches showed a continued steady trend upward (Fig. 1A).

In contrast to the large species, which were caught in record-high numbers in 1989, the numbers of small prey species entangled in the coarser mesh of the gillnet showed a continued downward trend (Fig. 1B). Numbers of large smelt were among the lowest seen in the 28-year period, but were slightly higher than in the previous year. Very few large alewife were entangled in the coarser mesh, and the numbers of yellow perch caught were at an all-time low.

Over the years, trawl catches of smelt in the Outlet Basin have increased (Fig. 2A). It is estimated from the 1989 gillnet catches that trawl catches would have supported this trend. Since the late 1970s, trawl catches of smelt have increased while gillnet catches have decreased. The trawls take much smaller smelt, which have increased in abundance in the Outlet Basin as a result of size-selective predation by the lake trout. Catch statistics from bottom trawling done by Fisheries and Oceans Canada in the vicinity of Main Duck Island in the summer of 1989, when compared with concurrent trawling conducted by Research and Fisheries and Oceans

Canada in other years, indicate that Research trawls in 1989 might have been expected to catch 50% more smelt and twice as many alewife as estimated from the gillnet correlates. This all suggests that the smelt normally sampled by trawls in the Eastern Basin were at least as abundant in 1989 as in 1988 and possibly 50% more abundant and that the smaller alewife on the bottom were probably more abundant.

The increased abundance of alewife in 1989 was confirmed by some sampling with floating gillnets that was conducted during the past two yr for spawning alewife inshore in the vicinity of the Upper Gap of the Bay of Quinte. In this area, spawning alewife were approximately five times more abundant in July 1989 than in July 1988. Indeed, spawning congregations inshore at this location in 1989 were similar to the record large catches taken with floating gillnets in the upper St. Lawrence River in the mid 1960s (Casselman, unpublished data) when the Lake Ontario alewife population was at record-high levels.

Future Directions

Subsampling to determine the relationship between observational variability and catch associated with this long-term data set will continue in 1990. From this research, it will be possible to estimate the sampling variability associated with this extensive data set. This will make it possible to measure the significance of various changes in species abundance with time. Special emphasis will be placed on examining the validity of age assessment in this data set and developing appropriate techniques so that accurate ages can be obtained to determine year-class strength for lake whitefish and lake herring and eventually for smelt, alewife, and sculpin. A detailed analysis of species interactions in this long-term data set will commence in 1990 once sampling variability can be estimated and valid age interpretations are available, commencing with lake whitefish.

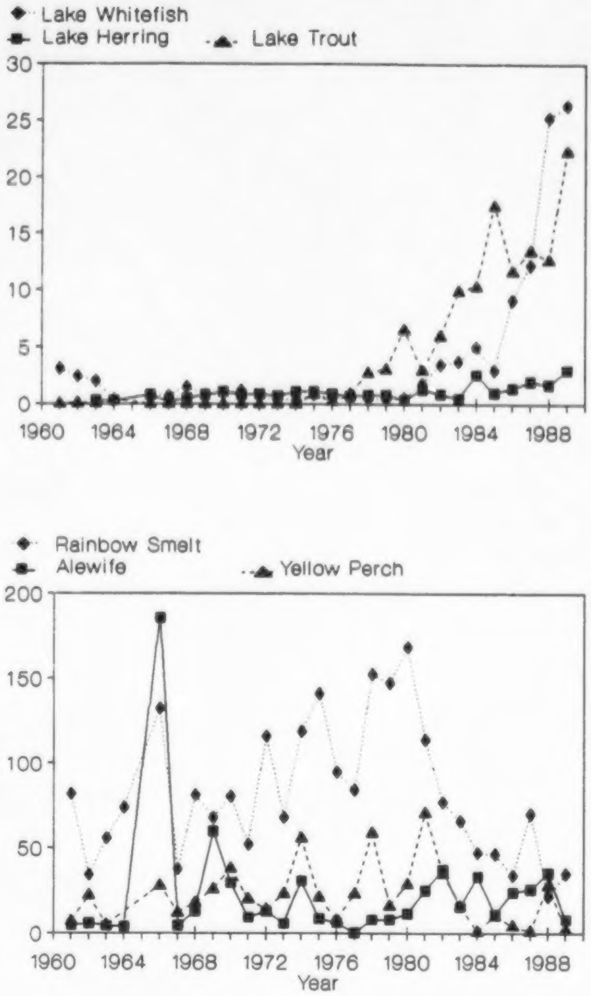

FIG. 1. Relative abundance of A) lake trout, lake whitefish, and lake herring and B) rainbow smelt, alewife, and yellow perch in the Outlet Basin of Lake Ontario, 1961 - 1988, as indicated by numbers caught in experimental gillnets set 26-38 m deep. Six stations were sampled once during May, June, July and August, and the results were averaged. Experimental gillnets were white multifilament 8 ft (2.44 m) deep and were composed of two 25-yd (22.86 m) panels of 1.5- and 2-inch mesh and two sets of eight 50 yd (45.72 m) panels ranging from 2.5- to 6-inch mesh stretch in 0.5-inch intervals. Lake trout catches were fish taken in July in 4.5-inch mesh. Alewife catches were fish entangled in 3.0-, 3.5-, and 4.0-inch mesh. Smelt catches were fish entangled in 2.5-, 3.0-, and 3.5-inch mesh.

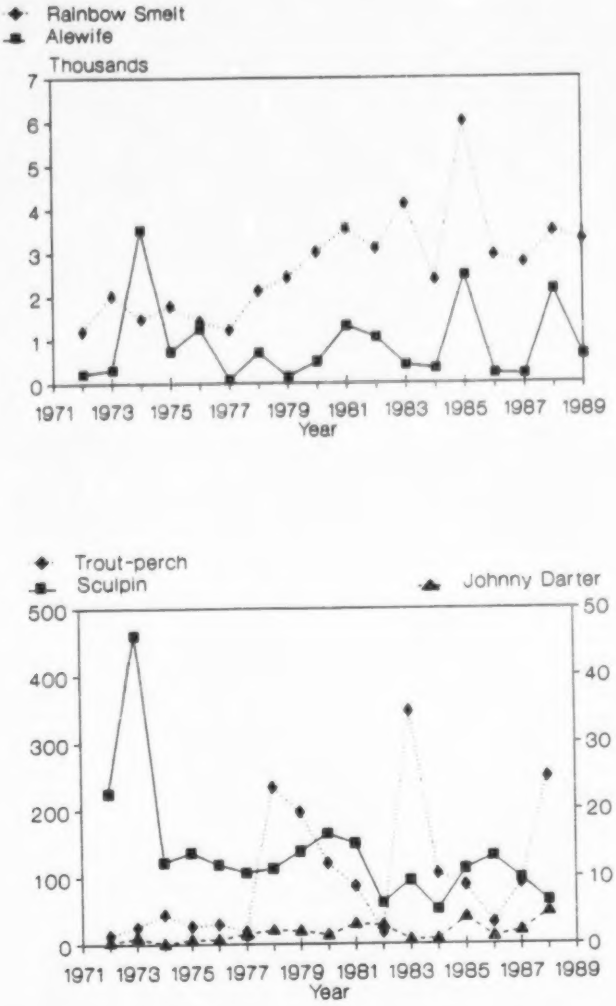

FIG. 2. Relative abundance of A) rainbow smelt and alewife and B) trout-perch, slimy sculpin, and Johnny darter in the Outlet Basin of Lake Ontario, 1972 - 1989, as indicated by number caught in a 1-mile (1609.34 m) tow of a three-quarter "Yankee Standard" number 35 bottom trawl drug at depths of 26-38 m. Six stations were sampled once during May, June, July, and August, and the resutls were averaged. The trawl had a 0.5-inch cod end; however, from 1977 to 1988, with the exception of 1983, a 0.25-inch mesh liner was used.

Research Project: Fish Community Studies of the Bay of Quinte.

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1. Long-term Gillnet Series.

This series is continuous from 1958 and provides an excellent method of following changes in fish species and abundance. Using standard gillnets of various mesh sizes allows estimates of year-classes of several important species.

The standard gillnet consists of a series of multifilament nets, with stretched mesh sizes from 38 to 127 mm in 13 mm increments, all tied end-to-end as one net. Lengths varied from 22.8 m for mesh sizes up to, and including 64 mm, with 45.7 m for each of the remaining mesh sizes. Nets were fished for about 24 h and catches were calculated on the basis of 91.4 m of each mesh size. Arithmetic means were calculated from the catches made in June and August at each of three sites in the bay.

The mean arithmetic CUE for the years 1986 through 1989 are given in Table 1 so that trends in the last few years can be followed. Several species were not as abundant at Big Bay in 1989 as they were in former years. Included in this group are: longnose gar, alewife, channel catfish, and white perch. Species such as gizzard shad and walleye were not taken as frequently in 1989 as in 1987 and 1988 but no consistent trend was noticed. White sucker, yellow perch, and freshwater drum all showed increases from previous years. Yellow perch were particularly abundant in 1989.

At Hay Bay, alewife abundance was substantially less than that recorded in 1988 and was more in line with levels seen in previous years. Similarly, gizzard shad were greatly reduced in 1989. White perch numbers were somewhat less than in previous years while walleye were somewhat more abundant in 1989. Other species showed little change from previous years.

Alewife abundance was considerably reduced at Conway over earlier years. Yellow perch numbers were also less in 1989. Lake trout, however, have shown consistent increases in the last few years. Other species showed little change.

This series has provided much valuable information on species shifts in the bay over the past few decades. Biological data gathered on subsamples of these catches have been used to calculate growth rates of several species, and the effects that changing abundance and altering climatic conditions have on growth and mortality. Changes are foreseen in the methodology in the next few years necessitated by the need to switch to monofilament twine. This will require extensive calibration between the multifilament and monofilament nets over the next two years so that conversion factors can be calculated.

2. Variance Associated with Gillnet Sets.

In order to provide an estimate of experimental error in the CUEs calculated from experimental gillnets, replicate sets were made at all three sites and in June and August. In this way the confidence limits around estimates can be reduced and year-to-year differences in abundance become more meaningful. The coefficient of variation was used to compare the amount of variability in the different populations since this measure is independent of the mean. Geometric mean values were used since these reduce the effects of extreme values.

Catches at Big Bay represented a typical warmwater community (Table 2). Temperatures in June ranged from 20 to 24 C and from 20 to 21.5 C in August. The CV was less than 20% for the more common species such as brown bullhead, freshwater drum, white sucker, white perch, walleye, and yellow perch. It was high for species that were relatively rare in the catch such as, channel catfish, northern pike, rock bass, and smallmouth bass. It was also high for alewife because CUEs ranged from 0 to 290 in the series. This reflects the schooling behaviour of this species and the chance encounter of a school by a gillnet. Gizzard shad were rare in the June catches but relatively frequent in the August catches and the low CV in August indicates this fact.

The catches in the lower bay at Conway reflect the coldwater community in June when temperatures were between 11.1 and 15.1 C. Lake trout were abundant in June but not in August when water temperatures were between 17 and 20 C (Table 3). The CV was low for alewife, and white sucker in June. The August replicates contained more rock bass, white perch, walleye, and smallmouth bass.

The catches in June at Hay Bay illustrated the effect of temperature in altering species composition (Table 4). Examination of the geometric mean catch for the six nets in June showed very high CV values for most species. Water temperatures over the period June 27 to July 7 ranged between 12.5 and 22.5 C. When the catches were separated at 19 C, two distinct groups emerged as seen in Table 4. Below 19 C there was a coldwater community where lake herring, lake trout, and rainbow smelt were taken, while above 19 C the cool and warmwater communities predominated. Catch levels for many species were low and this tended to magnify the variance for those species.

An examination of weather conditions in the area in late June provided some interesting insights. Data in Table 5 show water temperatures recorded at the net sites in Hay Bay and air temperatures and wind direction recorded at

Kingston, about 45 km east of Hay Bay. There is a negative correlation between the air and water temperatures, but not a significant one. Looking at the wind direction for this period shows that warmer air temperatures are associated with south winds, a not unexpected result, as cooler temperatures are related to north or west winds. However, water temperatures at Hay Bay were higher in periods of west and north winds and cooler in south winds. It appears that wind direction is influential in directing warmer or cooler water masses in this section of the Bay of Quinte. In light of known water movements in Adolphus Reach/North Channel in response to wind stress, it appears that Hay Bay is regularly exposed to altered temperatures especially in early summer. This further complicates the use of Hay Bay as a long-term monitoring location. Close examination of water temperature records over the years will be needed in interpreting fish abundance in Hay Bay.

The August catch at Hay Bay reflect the coolwater community (Table 6). Water temperatures ranged from 20.8 to 21 C. The lowest CVs are associated with the most abundant species. Values for yellow perch, walleye, and freshwater drum were particularly low.

One important conclusion from this work is that the serial replicates were not true replicates because conditions that affected the sampled populations were not consistent. The gear, therefore, was sampling different populations. This was particularly evident at Hay Bay in June when the temperature variation in 11 days was 10 C. One way to overcome this difficulty is to subsample each net that is fished so that the replicates are simultaneous. An important outcome of these tests is that the amount of gear fished as a unit-of-effort is sufficiently large that its sampling ability is fairly consistent. For that reason the CV obtained from six replicates was not greatly different from that obtained from three replicates. This increases the degree of confidence in the ability of the unit-of-effort to sample the population in a representative fashion.

3. A Comparison of Bay of Quinte and Kingston Basin Experimental Gillnet and Bottom Trawl Catches

The long series of gillnets and trawls used at specified sites in the Bay of Quinte and the Kingston basin of Lake Ontario were examined to see what correlations exist between these two data sets.

While the gillnet material in both series was the same, there was greater depth (2.44 m) in the Kingston basin sets compared to the Bay of Quinte sets (1.83 m). In addition, the lengths of net used tended to be greater in the Kingston basin than in the bay. An adjustment, therefore, was made to the bay catches by multiplying these catches by 1.349 to make them comparable to the Kingston basin catches.

Alewife were generally very abundant in the Kingston basin and the Bay of Quinte. A continuous series of gillnet sets began in 1961 where indices of abundance were calculated from sets made in June through August.

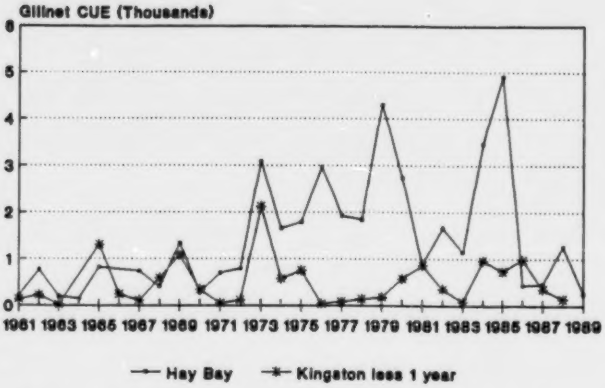

FIG. 1. Mean June - August gillnet CUE for alewife at Hay Bay in the Bay of Quinte and Kingston basin lagged by one year.

When the values of CUE for Hay Bay in the Bay of Quinte and Kingston basin were compared, there was no significant correlation between them (r = -0.005). However, it was noted that peaks and troughs occurred in the Kingston basin one year after the similar pattern was seen in the Hay Bay catch. Using the whole series from 1961 to 1989, the correlation was improved but still not significant (r = 0.258 d.f. = 23). Examining the graphed values (Fig. 1) showed that up to 1976 the correspondence in the two sets was quite high but from 1976 on, the pattern broke down. When the correlation for the 1961 - 1975 data set was calculated, it was highly significant (r = 0.876, d.f. = 10).

Growth rates for young alewife are much greater in Hay Bay than in the Kingston basin so the fish would become vulnerable to the nets sooner in Hay Bay. This would explain the one year lag in CUE values for the Kingston basin alewife.

The crash in the Lake Ontario alewife population in 1976 was reflected in the small catches in the next few years in the lake (Fig. 1). Strong year-classes were produced in the Bay of Quinte in those same years possibly assisted by a lower predation on young alewife by the older alewife.

When catches from bottom trawl drags were compared, there was a significant correlation between Kingston basin catch and the catch at Conway in the lower Bay of Quinte (r = 0.652, d.f. = 15). There was no time lag in the data set for trawl catches which fits the suggestion that growth differences caused the gillnet catches to be lagged.

Rainbow smelt was the only other species that was caught regularly both in the bay and in the Kingston basin. Trawl catches in the lower bay were significantly correlated (r = 0.717, d.f. = 15) with the Kingston basin catches..

Within the Bay of Quinte itself, only a few species showed a correlation in abundance at different locations. White perch numbers were correlated between the upper and middle bay sites but not at the upper and lower bay sites. Both yellow perch and walleye numbers were significantly correlated between Hay Bay and Conway but not at other locations. No significant correlation were found for white sucker, brown bullhead, rock bass, pumpkinseed, and smallmouth bass. This would suggest that these species do not travel widely within the bay and local populations are fairly distinct.

Table 1. Mean catch per standard gillnet lift in the Bay of Quinte.

Big Bay

Species	1986	1987	1988	1989
Longnose Gar	0	41.5	14.0	7.0
Alewife	422.5	178.0	43.3	53.9
Gizzard Shad	10.5	22.5	143.7	24.7
Lake Trout	0	0	0	0
Bullhead	43.0	62.0	40.3	57.5
Channel Catfish	14.5	31.0	29.7	5.7
White Sucker	29.9	26.5	25.3	57.4
Northern Pike	5.0	5.0	3.7	4.5
Pumpkinseed	0.5	0.5	0.3	0.5
Smallmouth Bass	6.0	2.0	8.7	3.5
White Perch	482.0	713.0	696.7	440.9
Yellow Perch	163.5	123.0	72.0	614.8
Walleye	35.0	110.0	82.3	59.5
Freshwater Drum	32.5	35.0	41.3	50.7

Hay Bay

Species	1986	1987	1988	1989
Longnose Gar	0	0	0	0.2
Alewife	249.0	191.5	929.3	194.0
Gizzard Shad	2.5	2.5	218.0	47.2
Lake Trout	0	0	0.7	0
Bullhead	45.5	16.5	18.0	12.0
Channel Catfish	1.5	0	4.5	1.5
White Sucker	7.0	23.5	10.7	15.4
Northern Pike	1.0	5.5	1.3	3.7
Pumpkinseed	1.0	0.5	2.0	5.9
Smallmouth Bass	7.5	4.0	0.7	6.7
White Perch	99.5	83.5	93.0	72.0
Yellow Perch	478.0	300.5	514.0	699.0
Walleye	49.5	13.5	25.7	46.5
Freshwater Drum	23.5	7.01	6.7	17.7

Conway

Species	1986	1987	1988	1989
Longnose Gar	4.5	0	0	0
Alewife	808.0	738.5	385.9	202.0
Gizzard Shad	0.5	0	20.0	9.4
Lake Trout	11.5	4.5	34.0	47.7
Bullhead	1.0	0	0	0
Channel Catfish	0	0	0.8	0.7
White Sucker	50.5	127.0	78.3	67.2
Northern Pike	0.5	0	0.5	0
Pumpkinseed	1.5	0	3.0	0
Smallmouth Bass	4.0	1.0	15.8	6.8
White Perch	59.0	70.5	26.7	40.5
Yellow Perch	1189.0	947.0	1155.7	610.5
Walleye	78.5	23.5	30.5	27.4
Freshwater Drum	1.0	0	50.8	20.8

Table 2. Geometric mean gillnet CUE at Big Bay, 1989.

Species	June 27 - July 6 Geometric Mean (N=6)	CV%	August 29 - 31 Geometric Mean (N=3)	CV%
Alewife	3.87	58.9	1.23	173.2
Bullhead	3.05	17.5	81.5	616.7
Catfish	1.03	88.2	1.82	97.2
Drum	4.51	16.7	49.51	12.3
N. Pike	1.06	60.9	1.97	93.2
Rock Bass	0.96	58.4	0.00	
Smallmouth Bass	0.89	57.6	2.17	86.8
Gizzard Shad	0.5	587.4	43.5	317.2
White Sucker	5.64	16.9	25.6	86.3
White Perch	10.44	10.5	637.3	75.5
Walleye	4.83	17.6	60.1	77.9
Yellow Perch	18.30	7.8	256.92	7.6

Table 3. Geometric mean gillnet CUE at Conway, 1989.

Species	June 27-July 6 Geometric Mean (N=6)	CV%	August 29 - 31 Geometric Mean (N=3)	CV%
Alewife	285.21	13.1	18.50	87.7
Brown Trout	2.32	86.0	9.04	23.9
Lake Trout	83.0	59.7	3.49	108.9
Rock Bass	6.43	91.0	8.08	41.3
White Sucker	62.85	8.9	74.9	25.5
White Perch	5.23	111.0	48.0	529.0
Lake Whitefish	3.55	34.6	0.43	173.2
Walleye	9.01	77.9	35.04	12.3
Yellow Perch	385.05	30.5	276.95	10.5
Smallmouth Bass	0.00	-	11.85	26.2

Table 4. Hay Bay gillnet catch, June - July 1989.

Species	All Nets Geo.Mean	N=6 CV%	<19.0°C Geo. Mean	N=3 CV%	>19.0 °C Geo. Mean	N=3 CV%
Alewife	180.3	32.6	77.1	43.9	419.7	19.6
Brown Trout	0.2	244.9	0.0	-	0.5	173.2
Bowfin	0.2	244.9	0.0	-	0.5	173.2
Bullhead	1.7	155.1	0.0	-	6.2	86.8
Carp	0.2	244.9	0.0	-	0.5	173.2
Catfish	0.2	244.9	0.0	-	0.5	173.2
Drum	2.2	116.0	0.0	-	9.3	30.2
Longnose Gar	0.2	244.9	0.0	-	0.5	173.2
Lake Herring	1.9	119.4	3.7	97.7	0.8	173.2
Lake Trout	0.3	244.9	0.8	173.2	0.0	-
Largemouth Bass	0.3	244.9	0.0	-	0.7	173.2
N. Pike	3.2	72.1	1.1	86.6	7.3	43.0
Pumpkinseed	1.02	44.9	0.0	-	2.8	173.2
Rock Bass	2.5	125.1	0.7	173.2	5.9	99.0
Smallmouth Bass	4.3	84.2	1.1	173.2	12.2	32.3
Gizzard Shad	1.5	118.0	0.0	-	5.4	34.6
Rainbow Smelt	2.0	113.1	4.1	87.6	0.8	173.2
White Sucker	10.8	50.8	17.7	53.8	6.4	44.8
White Bass	0.3	244.9	0.0	-	0.7	173.2
White Perch	8.4	82.9	1.5	90.9	34.1	45.9
Walleye	13.0	86.5	1.5	91.2	77.6	42.3
Yellow Perch	640.6	12.2	413.5	12.4	991.3	9.3

Table 5. Water temperature and wind conditions, late June and early July, 1989 at Hay Bay and Kingston Airport.

Date	Water Temp.(°C) Hay Bay Gillnet 6 m	Air Temp. Mean (°C) Kingston	Mean Wind Speed (km/h)	Prevailing Wind Direction
June 27	18.5	22.9	15.5	S
28	22.0	19.4	17.6	WSW
29	22.5	16.7	11.2	N
July 5	12.5	22.0	1.5	S
6	17.0	22.7	9.9	S
7	19.7	20.5	10.6	N

Table 6. Geometric mean gillnet CUE at Hay Bay, August 1989.

Species	Geometric Mean (N=3)	CV%
Bullhead	12.81	48.2
Channel Catfish	1.14	173.2
Drum	31.93	5.6
Gizzard Shad	49.55	36.0
Longnose Gar	0.47	173.2
Largemouth Bass	0.75	173.2
Northern Pike	0.97	173.2
Pumpkinseed	1.90	95.6
Smallmouth Bass	1.54	173.2
White Sucker	8.99	47.0
White Perch	117.8	26.7
Walleye	14.09	16.6
Yellow Perch	603.14	3.4

Research Project: Sampling Variability Of The Fish Community Of The Outlet Basin Of Lake Ontario

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Background and Objectives

Each summer for the past 28 years, the fish community of the Outlet Basin of Lake Ontario has been intensively sampled to study factors affecting changes in species abundance and interaction. This sampling program has used bottom-set gillnets at six fixed stations in the deep water (26-38 m) of the Outlet Basin and has consisted of sampling monthly from May to August, inclusive. Since 1972, bottom trawling has been conducted along with the gillnetting.

Over the years, the sampling methods have been extremely consistent and have involved relatively large single units of effort. However, replication of sampling procedures has not been a part of the design. The gillnets have been set as two gangs, one with mesh sizes ranging from 1.5 to 6 inches, and the other using only coarse mesh ranging from 2.5 to 6 inches. In 1989, two fine-mesh panels (1.5- and 2-inch) were added to the gang with the coarse mesh, creating two identical experimental gillnet gangs that were fished at each station. Each mesh size is fished in a 50-yd (45.72 m) panel, and catches are separated by mesh size.

Trawling has been conducted with a 3/4 "Yankee Standard" No. 35 bottom trawl, and a single long drag covering 0.5 mile was made at each station. As with the gillnets, since the trawling distance is relatively large, sampling variability would be expected to be low, but station trawling has not been replicated as part of the sampling design. It is essential that the observational variability associated with this gillnetting and trawling be measured if the true significance of changes in the relative abundance of fish in this valuable long-term data set are to be quantified and evaluated.

The purpose of this project is to measure and examine the observational variability associated with sampling the fish community of the Outlet Basin so that the significance of relative changes in the gillnet and trawl catches can be determined. Although this study is being conducted to measure the specific observational variability associated with the long-term data set and the deepwater fish community of the Outlet Basin, it is also designed to examine the general importance of such variables as (1) species, (2) location, (3) depth, (4) month, and (5) type of gear.

One of the primary goals of this program is to measure and hindcast the variability associated with previous sampling in this long-term data set. The plan was to obtain some measure of variability that would be correlated with abundance and could be used to estimate variability when abundance was known.

Several types of studies are included in this project, such as various types of sampling procedures with both multifilament and monofilament gillnets, replication, and subsampling. Some results reported briefly here are: (1) in 1989, replicate subsampling with standard experimental multifilament gillnets; (2) in 1988, replicate trawling; (3) in 1988, comparative gillnetting with monofilament gillnets used in conjunction with the standard experimental multifilament gillnetting; (4) in 1988 and 1989, some replicate sampling with monofilament gillnets, and from 1986 to 1988, replicate multifilament gillnetting at the deeper sets (20-30 m) of the index series conducted inshore in the Outlet Basin by Assessment.

Progress

Replicate Subsampling of Gillnets

Ideally, observational variability would be determined by replicate sampling. However, this is often difficult to achieve, especially if the effort is already large. Sampling in the Outlet Basin series is intensive; true multiple replication of this effort would be costly, destructive, and difficult to conduct in comparable time and space. It would be more appropriate to estimate variability by subsampling. Although this procedure has some drawbacks when compared with true replication since the variability must be extrapolated to the larger effort, it is a practical approach and provides a reasonable estimate when projected to the larger unit of effort. In 1989, each panel of each mesh of the standard multifilament gillnet was subdivided and subsampled by 50-ft (15.24 m) intervals. The variability was then estimated for the subsamples, and the observational variability for the entire net was projected from these results. The projected observational variability of the full net was estimated by dividing the variability determined for a net composed of 50-ft subsamples by the square root of 6 (2.45) since the full net is six times the size of the subsample net. This extrapolation can be performed because the reduction in sampling variability would be roughly proportional to the square root of the effort.

Sampling variability for each species was measured by adding 1 to the catch to eliminate zero observations. Then the catch data were log-transformed to calculate the coefficient of variation (CV--%). Catches were usually expressed as geometric mean values by subtracting 1 from the antilog of the mean of the log-transformed data.

When the observational variability and the geometric mean of a catch composed of 50-ft subsamples were compared, highly significant log-log correlations were obtained for the four species that were most frequently caught in the gillnets (Table 1). The lowest of these correlations was for lake whitefish and the highest for rainbow smelt.

These positive results were encouraging, because they indicated that for these four species, the sampling variability can be predicted from the size of the catch. Predictive regressions of variability and catch were also calculated for these four species (Table 2). The regressions use log arithmetic mean catch for the entire standard experimental gillnet (both gangs) regressed on the projected coefficient of variation calculated for the entire net from the subsamples (divided by the square root of 6--2.45).

Although these relations are highly correlated, the range in the size of the individual 1989 catches used to construct them was not so great as has been observed over the past 28 years of sampling. Therefore, additional subsampling effort, if possible involving the extreme catches, is needed. Nevertheless, the correlations indicate that with some additional sampling, relations can be constructed for the major species that will make it possible to determine sampling variability from previous catch data.

Estimates of the observational variability of the standard experimental gillnet set at each station in 1989 indicated that lake trout catches are extremely consistent. With this amount of gillnet effort (1,958.56 m^2), the coefficient of variation for lake trout is projected to be only 3.3% (Table 3). Sampling variability for the other three species was higher, but is generally quite low for gillnets because of the intensive effort (CV for alewife--12.1%, rainbow smelt--15.2%, lake whitefish--21.9%).

For these four species, sampling variability was lowest for lake trout and highest for rainbow smelt and varied among the six stations (Table 3). Sampling variability was greatest at Station 4 for all species except lake trout. Within stations, there were obvious seasonal trends. Variability in alewife catches increased from May to August, while it decreased for lake whitefish and rainbow smelt during the same period. Lake trout catches did not show any simple trends, but were most variable in May and August and least variable in July.

Replicate Trawling

Replicate trawling was conducted at each of the six stations during May, June, July, and August, 1988. It involved three to four multiple drags on adjacent substrate. The catch data were analysed by using the same methods employed on the gillnet catches. In this case, sampling variability of all species normally taken in the trawls, with the notable exception of alewife, was highly correlated with the geometric mean size of the catch (Table 4). These results for alewife are not surprising, considering that the species is usually pelagic and has a strong schooling behaviour. Additional sampling will be needed to confirm whether these preliminary observations for alewife caught by bottom trawling in the deeper areas of the Outlet Basin are typical. Results for the other species indicate that it will be possible to estimate sampling variability by using the size of the trawl catch. Lake trout showed the highest correlation (Table 4), even though individual catches were small (CV = 2.0%) and the coefficient of variation was quite high (CV = 108.3%). For any particular species, trawl catches had a higher variability than did the gillnet catches (alewife--2.4x, lake trout--32.8x, lake whitefish--3.8x, rainbow smelt--1.2x). This is expected, however, because trawls catch smaller, younger fish, which have a higher sampling variability.

Comparative Monofilament-Multifilament Gillnetting

In 1988, monofilament gillnets were set along with the standard multifilament gillnets. The experimental monofilament gillnets were chosen for this comparison because they have relatively short panels (50 ft, or 15.24 m) and their observational variability had already been studied thoroughly on coldwater fish communities in deep, oligotrophic inland lakes similar to the Outlet Basin. Although the monofilament gillnet contained some finer meshes, for purposes of this comparison, only meshes that were comparable in size (1.5 inch mesh) were used in these comparisons. When the two types of nets were compared, the actual variability of the catch in the monofilament gillnet was adjusted to reflect the same amount of effort used with the two gangs of multifilament nets. In 1988, the multifilament nets (1,958.57 m^2) that were set at each station exerted 6.59 times as much fishing effort on an area basis as did the monofilament nets (297.29 m^2). To examine the importance of depth, catches were subdivided by sampling depth into two depth categories--shallow, 20-30 m; deep, 30-40 m.

From catches in the standard experimental multifilament gillnets set in the Outlet Basin in July and August from 1961 to 1988, it was apparent that regardless of depth, over the years smelt had the lowest annual sampling variability (CV = 19.2%--Table 5). Over this period, alewife (63.1%) and lake trout (80.9%) were taken with the next lowest annual sampling variability. The average sampling variability among the stations over this 27-year period has been high regardless of depth (Table 5), but as expected, the variability for most species varied over the years in relation to size of the catch. This has been best exemplified by lake trout. Sampling variability for this species was high (200%) when the catches were low in the 1960s. However, now that catches are high, this variability is 20%, an order of magnitude lower.

Since monofilament gillnets were set along with the standard multifilament gillnets in 1988, it was possible to examine some of the intrinsic differences associated with these two types of gear. In addition to differences in the type of twine, the two nets have different hanging ratios. The monofilament gillnets were constructed with the conventional experimental gillnet hanging ratio of 0.5 (web to line--2:1), whereas the experimental multifilament gillnets have a more extreme hanging ratio of 0.4 (web to line--2.5:1). This method of hanging produces a more oval diamond and is the way that commercial fishermen on Lake Ontario have traditionally hung their whitefish gillnets.

When the efforts of these two nets were standardized, the monofilament gillnets sampled the shallower depths 2.8 times more consistently than the multifilament nets (Table 6). At the deeper depths, this difference was almost twice as much (5.4 times). On the average, the experimental multifilament nets had 3.0 times the variability of the experimental monofilament nets and would require 10.6 times the effort to have the same level of sampling variability. The multifilament nets sampled smelt most consistently, although the variation was still greater (1.9 times) than with the monofilament nets. There was one very notable exception, which involved multifilament nets set in deep water (30-40 m). Under these conditions, lake whitefish were taken much more consistently in the multifilament nets than in the monofilament nets (Table 6). The variability was 4.1 times higher with the monofilament gillnets and to obtain the same level of variability, 16.4 times as much monofilament gillnets would need to be used. It is not surprising that the multifilament nets took lake whitefish more consistently in deep water than the monofilament nets and more consistently than any other species. These gillnets have material and hanging ratios identical to the nets referred to as "whitefish nets" that have been developed and have been used for many years by fishermen who commercially gillnetted whitefish in the deep water in the Eastern Basin.

Indeed, with the exception of smelt, which appear to tangle by their teeth more easily in multifilament than in monofilament twine, those species which had relatively low sampling variability in the multifilament nets were the large, slab-sided species; e.g., lake herring, lake whitefish, rockbass, and brown trout. The cross-sectional shape of these species more closely conforms to the oval diamond created by the extreme hanging ratio used in these multifilament nets.

Replicate Monofilament-Multifilament Gillnetting

Sampling variability among the six stations in the Outlet Basin was examined, using catches made with the monofilament gillnets fished in 1988. These results were compared with within-station variability, which was determined with identical monofilament gillnets fished during the same period in the Outlet Basin southeast of Yorkshire Island. This provided the best measure of observational variability since three to five replicate sets were made at each site (Table 5). The actual variability in the catches of the monofilament gillnets was adjusted to reflect the variability associated with the same amount of fishing effort as was routinely applied with the multifilament gillnets. These results provide a measure of the observational variability observed when sampling the Outlet Basin and indicate the homogeneity of the fish distribution within this area. Where species could be compared, the among-station variability, when compared with within-station variability, was an average of 3.5 times greater for the shallower sets and 8.0 times greater for the deeper sets (Table 5).

Similar comparisons were made for replicate multifilament gillnet catches obtained from the inshore assessment series in the Outlet Basin. The observational variability among the six deep-water stations, when compared with the within-station variability from 1986 to 1988, was 2.4 times greater (Table 7). The actual observational variability as determined by replicate gillnet sampling for the eight most abundant species taken in these nets was quite high (average CV = 77.0%). Indeed, only three species (smelt, alewife, and lake trout) were sampled with a variability that was less than 40%.

Future Directions

Replicate sampling of the standard experimental multifilament gillnets set at the six deep-water stations will be conducted for one more year. This will be conducted to confirm and expand the correlations obtained in 1989 and if possible extend the regression with more extreme values (high and low catches). After the 1990 data are collected and analysed, it is expected that the variability associated with gillnet sampling in this long-term data set will be adequately quantified and understood.

Replicate trawling will continue in 1990. Since trawl catches for some species are extremely variable, additional studies of trawl sampling variability and replication will be needed. It is expected that replicate sampling or subsampling to estimate variability will become routine for research sampling in the future. Under certain conditions, the extremely large single units of gillnets that have been used in the past could have been reduced. However, unless sampling variability is measured routinely, the amount of effort and associated variability cannot be evaluated.

Research is planned to determine if practical, predictive relations can be developed that will make it feasible to design a monitored sampling program that can be conducted interactively so that it applies just enough effort to attain a specified level of sampling variability.

Table 1. Log-log relations between the observational variability expressed as coefficient of variation (CV) and the geometric mean catch for four species caught in 50-ft (15.24 m) subsamples of the standard white multifilament experimental gillnets ranging in mesh sizes from 1.5 to 6 inches fished in the Outlet Basin of Lake Ontario 26-38 m deep at six stations during 1989, once during each of May, June, July, and August. The variation was calculated by subsampling the catch of the standard net. Six subsamples, each composed of 50-ft (15.24 m) intervals, were drawn from each mesh size. Catch of the 50-ft interval net is expressed as numbers and CV as percent. Sample sizes, correlation coefficients, and probabability levels are provided.

Species	Regression equation		N	r	P
	dependent variable CV	independent variable geom. mean catch			
alewife	LogY = 1.979 - 0.570LogX		24	0.798	0.000
lake trout	LogY = 1.841 - 0.785LogX		24	0.748	0.000
lake whitefish	LogY = 1.692 - 0.359LogX		23	0.599	0.000
rainbow smelt	LogY = 1.807 - 0.651LogX		24	0.932	0.000

Table 2. Predictive regressions of the log-log relations between the arithmetic mean catch and the projected observational variability expressed as coefficient of variation (CV) for four species caught in the standard white multifilament experimental gillnet ranging in mesh size from 1.5 to 6 inch fished in the Outlet Basin of Lake Ontario 26-38 m deep at six stations in 1989, once during each of May, June, July, and August. The variation was projected by subsampling the catch of the standard net by 50-ft (15.24 m) intervals. The projected variation was calculated by dividing the coefficient of variation of the subsamples by the square root of the effort (square root of 6--2.45). Catch of the entire net, composed of 2 x 150 ft (45.72 m) intervals of each mesh, is expressed as number and the coefficient of variation as percent. Sample sizes, correlation, coefficients, and probability levels are provided.

Species	Regression equation		N	r	P
	dependent variable arith. mean catch	independent variable CV			
alewife	LogY = 2.901 - 0.982LogX		24	0.727	0.000
lake trout	LogY = 2.408 - 0.714LogX		24	0.737	0.000
lake whitefish	LogY = 2.220 - 0.910LogX		23	0.582	0.001
rainbow smelt	LogY = 2.746 - 1.250LogX		24	0.916	0.000

Table 3. Mean catch (CUE) and projected observational variability expressed as coefficients of variation (CV) separated by station and month for four species caught in the standard white multifilament experimental gillnet ranging in mesh size from 1.5 to 6 inches fished in the Outlet Basin of Lake Ontario 26 to 38 m deep at six stations in 1989, once during each of May, June, July, and August. The variation was projected by subsampling the catch of the standard net by 50-ft (15.24 m) intervals. The projected variations were calculated by dividing the variation of the subsamples by the square root of the effort (square root of 6--2.45). Catch of the entire net, composed of 2 x 150 ft (45.72 m) intervals of each mesh, is expressed as number per 100 m^2 of net and the coefficient of variation as percent.

		Alewife		Lake trout		Lake Whitefish		Rainbow smelt	
Variable	N	CUE	CV	CUE	CV	CUE	CV	CUE	CV
Station No.									
1^a	4	8.8	10.3	5.0	5.3	0.8	14.9	9.7	5.3
2^a	4	8.1	6.9	3.9	4.6	1.5	17.1	4.8	5.2
3^b	4	5.8	9.5	8.5	2.7	0.3	23.3	3.3	7.2
4^a	4	4.9	14.6	10.7	2.3	1.6	42.5	0.9	45.9
5^a	4	11.3	10.1	8.2	2.6	1.4	11.3	2.9	20.0
6^c	4	3.2	21.4	7.7	2.4	1.2	22.0	3.6	7.5
Month									
May	6	5.8	8.2	3.9	4.6	0.4	36.9	1.5	25.0
June	6	8.3	8.9	8.6	2.5	0.5	25.2	1.8	25.7
July	6	5.5	13.9	11.1	1.6	1.1	18.1	6.1	5.0
Aug.	6	8.6	17.4	5.8	4.6	2.5	7.5	7.4	5.1
Overall mean	24	7.0	12.1	7.4	3.3	1.1	21.9	4.2	15.2

[a] Approximately 30 m deep.
[b] <30 m deep (approximately 25 m).
[c] >30 m deep (approximately 35 m).

Table 4. Log-log relations between the observational variability expressed as coefficient of variation (CV) and the geometric mean catch for five species caught in the Outlet Basin of Lake Ontario in a 1-mile (1609.34 m) tow of a three-quarter "Yankee Standard" No. 35 bottom trawl drug at a depth of 26-38 m. Four replicate drags were made in 1988, once during each of May, June, July, and August at six stations (except May). Catch is expressed as number and CV as percent. Sample size, correlation coefficients, and probability levels are provided.

	Regression equation				
Species	dependent variable CV	independent variable geom. mean catch	N	r	P
alewife	no sign. regression		15	0.033	0.656
lake trout	LogY = 1.890 - 0.549LogX		15	0.883	0.000
lake whitefish	LogY = 1.940 - 0.373LogX		16	0.645	0.002
rainbow smelt	LogY = 3.042 - 0.696LogX		19	0.775	0.000
slimy sculpin	LogY = 2.117 - 0.478LogX		19	0.831	0.000

Table 5. Average annual (July-August) sampling variability (CV) for experimental gillnets, by species, among the six stations in the Outlet Basin of Lake Ontario for the period 1961-1988, separated into two depth strata (20-30 m, 30-40 m). The nets were white multifilament with mesh sizes ranging from 1.5 to 6 inches. The variance is also provided for the 1988 monofilament experimental gillnet series with meshes ranging from 1.5 to 5 inch, adjusted to the same amount of effort used for the multifilament nets. The within-station variability that is provided comes from identical monofilament gillnets used in the juvenile lake trout study conducted in the St. Lawrence trench southeast of Yorkshire Island. The variance on the unadjusted actual catch of the monofilament gillnet is also presented. The results for the 20-30 m depth stratum in the Outlet Basin are compared with those for the 23.4-m depth southeast of Yorkshire and the 30-40 m stratum with the 31.1-m depth. A ratio of the comparison of the among-station variability to the within-station variability is provided.

	20-30 m depth						30-40 m depth					
	Average CV						Average CV					
	6 stations 1961-1988	CV among 6 stations 1988-monofilament		CV within station[a] 1988-monofilament		Ratio of	6 stations 1961-1988	CV among 6 stations 1988-monofilament		CV within station[a] 1988-monofilament		Ratio of
	multifilament	actual[b]	adjusted[c]	actual[b]	adjusted[c]	variability	multifilament	actual[b]	adjusted[c]	actual[b]	adjusted[c]	variability
alewife	63.2	35.7	13.9	12.5	4.9	2.9	63.0	2.4	0.9	15.4	6.0	0.2
lake trout	84.7	37.6	14.6				77.0	25.1	9.8	1.6	0.6	15.7
brown trout	185.8	316.2	123.2	173.2	67.5	1.8	282.8			172.2	67.1	
lake whitefish	107.3	84.3	32.8				144.7	62.5	24.3	5.1	2.0	12.3
lake herring	105.5	134.5	52.5				107.5			173.2	67.5	
rainbow smelt	22.4	69.8	27.2				16.0	62.4	24.3	16.3	6.4	3.8
white sucker	306.0	316.2	123.2				300.0					
trout-perch	273.1	161.0	62.7				231.1			173.2	67.5	
rockbass	198.1	252.9	98.5				196.3			183.2	71.4	
smallmouth bass	244.6	173.2	67.5	20.5	8.0	8.5	208.6					
yellow perch	123.6	108.0	42.1	123.2	48.0	0.9	118.8	141.4	55.1			
No. of species	11	11	11	4	4	4	11	5	5	8	8	4
Average	155.8	153.6	59.8	82.4	32.1	3.5	158.7	58.8	22.9	92.5 (9.6)[d]	36.1 (3.8)[d]	8.0

[a] Southeast of Yorkshire Island in the outlet basin of Lake Ontario.

[b] Actual variability for the monofilament experimental gillnet (297.29 m^2).

[c] Adjusted to the same effort used with the multifilament experimental gillnets (1958.57 m^2).

[d] Average for species for which variability was measured among the stations.

Table 6. Comparison of the relative variability in sampling species of the Outlet Basin in 1988 with the white multifilament experimental whitefish gillnets routinely used, as compared with the green monofilament experimental gillnets. Relative variability (consistency) is expressed as the ratio (CV multi/CV mono) variability of the multifilament gillnets in relation to that of the monofilament gillnets, corrected for the same effort on an area basis. The table shows the relative amount of effort required with multifilament nets to provide the same level of sampling variability among the six stations of the Outlet Basin as with monofilament nets. Gillnets ranged in mesh size from 1.5 to 6 inches, but with slightly different hanging ratios and colour--multifilament 2.5:1, white; and monofilament 2.0:1, green.

	20-30 m depth		30-40 m depth		all depths	
Species	consistency	effort	consistency	effort	consistency	effort
alewife	3.77	14.2	19.23	373.8	4.72	22.2
lake trout	3.47	12.0	1.95	3.8	2.86	8.2
brown trout	2.07	4.3			2.07	4.3
lake whitefish	1.70	2.9	0.25 (4.05)[a]	0.06 (16.4)[a]	1.92	3.7
lake herring	1.75	3.0			1.75	3.0
rainbow smelt	1.63	2.7	2.13	4.5	1.86	3.5
white sucker	3.63	13.2			3.63	13.2
trout-perch	3.38	11.4			5.21	27.1[b]
rockbass	2.00	4.0			2.00	4.0
yellow perch	4.78	22.8	3.63	13.2	4.13	17.0
No. of species	10	10	5	5	10	10
Mean	2.82	9.1	5.44 (6.74)[c]	79.1 (98.8)[c]	3.02	10.6

[a] Reciprocal relation (CV mono/CV multi).

[b] Includes some small catches from 30-40 m depth that were taken with zero variability in the monofilament gillnets.

[c] Excludes value for lake whitefish, average of 4.

Table 7. Average annual (July-August) sampling variability for experimental gillnets by species among six stations in the Outlet Basin of Lake Ontario for the period 1986-88 for the 20-30-m depth stratum. The nets were white multifilament with mesh sizes ranging from 1.5 to 5 inches. The within-station variability was determined for the deepest sets (N = 3) of the three index gillnet transects in the Outlet Basin by using nets with a 1.5-inch mesh panel of 4.57 m. The catch of this panel was adjusted so the effort was comparable to the nets used to sample the six Outlet Basin stations.

	CV among 6 stations 1986-88 multifilament	CV within 3 stations 1986-88 - multifilament		Ratio of variability
		actual[a]	adjusted[b]	
alewife	47.6	21.8	13.6	3.5
lake trout	33.0	35.3	22.0	1.5
brown trout	183.3	144.5	90.0	2.0
lake whitefish	80.9	69.7	43.5	1.9
lake herring	95.3	64.1	39.9	2.4
rainbow smelt	29.3	21.0	13.1	2.2
rockbass	230.5	160.9	100.3	2.3
yellow perch	210.0	98.4	61.1	3.4
No. of species	8	8	8	8
Mean	113.7	77.0	47.9	2.4

[a] Actual variance for the index gillnets (760.38 m^2).

[b] Variability adjusted to the same effort as that used with Outlet Basin station gillnets (1958.57 m^2).

Research Project: Lake Trout Rehabilitation Studies

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Background

In the past 13 years, more than 2.7 million lake trout have been stocked in Canadian waters in the Outlet Basin of Lake Ontario in an effort to rehabilitate lake trout stocks in Lake Ontario. However, it was not until 1984 that substantial numbers of mature lake trout appeared on traditional spawning shoals in the east end of Lake Ontario. It has been documented that these spawning congregations deposit viable eggs and that survival and hatch are high if the eggs are stripped, fertilized, and reared under artificial conditions. Although adequate spawning activity may not have gone on for very long in Lake Ontario, there is some evidence that egg deposition is extensive and that eggs and fry survive. Fry have been collected in small but consistent numbers from the bar at Stoney Island, but 100 fry traps deployed during the past two springs on Yorkshire Bar by the Assessment component of the Lake Ontario Fisheries Unit have caught only one lake trout fry. It is possible that fry and juvenile lake trout are present, albeit in small numbers, but have not been adequately sampled. However, it appears just as likely that egg or fry development and survival are not adequate. For this reason, two studies are being conducted: one involving eggs, fry, spawning, and spawning habitat, and the other involving juvenile abundance and their habitat requirements. This phase of the study involves sampling potential juvenile deepwater habitats to locate indigenous juveniles and also studying predators and their abundance.

Lake Trout Spawning and In Situ Egg Incubation - 1989 Study Update

Background and Objectives

In the fall of 1987 and 1988, a study of congregating and spawning lake trout on Yorkshire Bar was initiated. Fisheries Research at Glenora had gillnetted the bar at spawning time since 1975. With this catch information, it was possible to document the re-establishment of the spawning stock on the bar and to ascertain if this traditional spawning site is being used by any indigenous lake trout. The specific objectives of the study were to (1) study spawning congregations that were appearing on the bar, (2) determine the densities and behaviour of these fish, (3) determine if viable gametes were present and deposited, (4) measure the density of naturally deposited eggs in relation to available substrate, and (5) determine if these eggs survive, develop, and hatch.

Progress

Tagging studies conducted in the fall of 1987 and 1988 indicated that approximately 1,000 mature lake trout frequented Yorkshire Bay at peak spawning time in 1988. The majority of these fish were males; the highest percentage of ripe and running females was observed during the first week of November, slightly earlier in 1988 than in 1987. The same appeared to be true in 1989, since most of the small females collected by short-term gillnetting on November 4 were completely spent. The large, mature females taken at that time were ripe but not running freely.

In 1989, catches in a one-hour set of an experimental gillnet ranging in mesh size from 1.5 to 6 inches indicated that there were approximately five to seven times as many lake trout present in 1989 as in 1987 and 1988 (Table 1). The individuals were larger than in previous years (Table 1); however, the majority of the catch was male fish that were mature for the first time.

Some tags applied in previous years have been recaptured. These returns indicate that the lake trout which use Yorkshire Bar frequent the middle of the Eastern Basin in midsummer and are recaptured more often in the deeper, open portions of the lake. Disproportionately fewer of these returns have come from the Outlet Basin during the summer research netting. In fact, a disproportionately high percentage of the lake trout that frequent Yorkshire Bar in the fall originated from stockings in American waters. Tag returns to the bar are low (approximately 1-3%) and do not indicate any special fidelity to Yorkshire Bar in subsequent falls. In fact, one lake trout tagged on Yorkshire Bar in 1987 was caught on the Stoney Island spawning area in the fall of 1988.

A large number of male lake trout congregated on the bar in mid- to late October. They swam about in small groups of 20 to 40 individuals. When a diver worked on the bar installing incubators with control eggs on October 23, he reported that a large school of medium-sized male lake trout was schooling over the top and the east slope of the bar in water ranging in depth from 3 to 6 m over rubble ranging in size from 5 to 40 cm.

Table 1. Lake trout catch statistics for 13 years (between 1975 and 1989) for gillnets set at spawning time on Yorkshire Bar of Yorkshire Island and for standard Lake Ontario experimental multifilament gillnets set 26 to 38 m deep at six stations throughout the Outlet Basin in the east end of Lake Ontario. Catches are expressed as number and weight of lake trout taken in 100 m^2 of net in 24 hours. The catches in the 2.5- and 3.0-inch mesh panels of multifilament are expressed in the same units. The 1987, 1988, and 1989 (except 2.5- and 3.0 inch-mesh) netting was conducted with a slightly different type of gillnet (green monofilament).

	Yorkshire Bar spawning period						Outlet basin June-August		
	2.5-in and 3.0-in mesh			1.5 to 6.0-inch mesh experimental gillnet			1.5 to 6.0-inch mesh experimental gillnet		
	CUE			CUE			CUE		
Year	N	kg	Average wt (kg)	N	kg	Average wt (kg)	N	kg	Average wt (kg)
1975	0.00	0.00		0.40	0.06	1.508	0.22	0.21	0.966
1976	0.00	0.00		0.00	0.00		0.22	0.24	1.106
1977	0.28	0.47	1.68	0.47	0.78	1.646	0.41	0.35	0.857
1978	0.75	1.02	1.36	0.54	0.70	1.294	0.76	0.71	0.932
1979	0.30	0.47	1.55	0.36	0.73	2.048	0.94	1.32	1.402
1980	0.30	0.49	1.64	0.60	1.34	2.248	2.74	2.86	1.644
1981	1.39	2.42	1.74	1.21	2.95	2.426	1.77	2.27	1.279
1982	1.80	3.04	1.69	1.79	3.57	1.994	2.59	2.99	1.154
1983	4.19	9.60	2.29	4.96	12.30	2.481	4.19	6.04	1.442[a]
1984	16.73	42.49	2.54	19.84	52.11	2.626	5.38	10.38	1.929[a]
1985							6.73	13.88	2.062
1986							5.26	10.42	1.980
1987	[78.23	216.38	2.766][b]	[60.55	176.32	2.912][c]	10.49	21.59	2.059
1988	[137.20	389.00	2.835][b]	46.22	131.68	2.849[d]	6.32	13.62	2.156
1989	564.43	1659.44	2.940[b]	317.69	746.23	2.349[d]	8.80	20.37	2.317

[a] Estimated catch.

[b] Catch data for 2.5- and 3.0-inch mesh combined and adjusted for activity on spawning grounds to approximate the CUE for a 24-hour period to make the results generally comparable to other years.

[c] Estimated catch calculated from previous catch relationship between 2.5- and 3.0-inch mesh and 1.5- to 6.0-inch mesh experimental gillnet sets on Yorkshire Bar, since only 2.5- and 3.0-inch mesh gillnets were used in 1987.

[d] Catch data for 1.5- to 5-inch mesh, green monofilament, experimental gillnets set for 1 to 6 hours, and adjusted for activity on the spawning grounds to approximate the CUE for a 12-hour period to make the results generally comparable to other years.

Egg traps developed by Marsden, Krueger, and Horne have been deployed on the bar to try to quantify egg deposition. However, the sampling approach used in 1989 was different than that attempted in 1988. In 1988, the open versions of the trap, which is simply a hoop with tapered seine netting, were placed across the bar on chains, but were unsuccessful because when they were first set, they were caught in a storm and were severely damaged. No eggs were trapped. In 1989, 50 new version double-coned, plastic egg traps were installed on chains alternately with the 1988 hoop tapered seine-netting version. Twenty-five traps were deployed 1 m apart on four separate chains. These chains of traps were set just after dusk in a grid across the peak of the bar. They were deployed on four occasions: 2.5 h on October 25 when no eggs were caught, 3.3 h on October 30 when the 1988 version caught 4 eggs (an approximate deposition of 0.9 eggs per m^2), October 31, and November 1 when two eggs were collected, one in each version. A test that involved seeding eggs in the water column over the two types of traps indicated that the plastic (Marsden-Krueger) 1989 version has approximately half of the catchment area of the 1988 version. Trapping efficiency and the effective catchment area of the 1989 version must be determined for known deposition rates if it is to be used to obtain reliable absolute measures of egg deposition. There is evidence from the few eggs caught in 1989 that these traps catch not only eggs that have been deposited and are settling, but also eggs that are drifting along the substrate.

Divers were hired to conduct a systematic quantitative egg survey on the bar. Weather conditions prevented this survey. However, the divers made valuable observations concerning naturally deposited eggs when they worked on the bar installing incubators in the rubble on October 23 and November 8. No lake trout eggs were present in the rubble on October 23. However, on November 8, they provided observations from which it can be estimated that there were approximately 20 live eggs, 5 fungused eggs, and 40 empty egg shells per square metre of rubble in the 4- to 5-m depth range on the peak and the east slope of the bar. The eggs were located in rubble ranging from 5 to 30 cm in diameter and at a depth of 10 to 30 cm in the rubble. From a cursory examination of the peak of the bar over the 3 to 6 m depth range, they estimated that the greatest number of eggs were depositied at the 3-m depth. They reported that rubble on the peak of the bar had been cleaned when they saw lake trout schooling over the bar on October 23. The majority of these lake trout frequented the peak of the bar over a depth range of 3- to 6-m and a short distance down the steeper east slope of the bar. On November 8, they reported the presence of large numbers of small crayfish and small slimy sculpins in the interstitial spaces of the rubble. They also remarked that on November 8, the water was much more turbid than in October, and they reported greyish mucoid strings in the shallow interstices of the rubble in the general area where the schools of lake trout were milling about in October. This material was later identified as faeces. When large numbers of lake trout are present, as on Yorkshire Bar this fall, their faecal waste could affect interstitial water quality. No eyed eggs were observed during either dive. However, when divers from Cornell University collected eggs on November 27 on Yorkshire Bar, 72% of the 142 eggs they collected were eyed. It was estimated that they had eyed up approximately 2 weeks earlier (Ellen Marsden, pers. comm.). When these eggs were reared in hatchery facilities at Cornell University, 90% of the sample finally eyed up by December 13, and by February 11, 1990, all eyed eggs had hatched (Peter Grewe, pers. comm.). These divers estimated that on November 27 at the peak of the bar in approximately 5.5 m of water (18-20 ft) there were 100 eggs per m^2 (10/ft^2), but one-third of these were dead.

Eggs were collected from lake trout on Yorkshire Bar on November 8, 1988, fertilized, and loaded in incubators to conduct an in situ study of survival and development. In 1988, the incubators were not installed on Yorkshire Bar because of weather conditions. The in situ incubation study was part of a joint Great Lakes study coordinated by the Great Lakes Fishery Commission. John Fitzsimmons of Fisheries and Oceans Canada installed the incubators on a shoal in the west end of Lake Ontario near Grimsby. Additional eggs from Yorkshire Bar were transported to Dr. Bruce Manny at Ann Arbor, Michigan, and were held in the Great Lakes fishery laboratory as controls. Eggs were also shipped to Jim Peck at Marquette, Wisconsin, where they were loaded in incubators and installed in artificial substrate in Presque Isle Harbor on Lake Superior. This study compares with controls the fertilization rates, early survival, development, hatch, and post-hatch survival for lake trout eggs and fry from lakes Huron, Ontario, and Superior. The specific results of this study will be reported elsewhere. However, Yorkshire Bar eggs had the highest fertilization rate (98%) and the highest in vitro hatching rate (80%), but, in contrast, had the highest proportion of deformed embryos (2.6%) and a consistently high mortality rate shortly after swim-up (23-32%). This has been called the "contaminate syndrome" and was not observed in fry from lakes Superior or Huron.

In situ incubation studies were started again in 1989. The research design was similar to 1988, but they involved Lake Michigan, the west end of Lake Ontario, and Lake Superior, and, as before, the controls are being held and reared at the Great Lakes laboratory at Ann Arbor. This year, additional control eggs were obtained from Lake Manitou and have been installed in all lakes, including 44 incubators on Yorkshire Bar. The incubators were placed alternately on side chains of two main chains laid along the contour on the edge of the peak of the bar, ranging from 4 to 4.5 m and 1 m deeper on the east slope of the bar on another chain. The incubators with Manitou eggs were installed on October 23. Forty-four incubators containing eggs of lake trout from Yorkshire Bar were installed on November 8. The lake trout actively frequented the rubble area where the in cubators were installed, and naturally deposited eggs were found among the chains and incubators (see estimated densities above) when the incubators of Yorkshire eggs were put down. Yorkshire Bar eggs have also been installed in incubators in Lake Superior and are being held as controls in the Great Lakes laboratory at Ann Arbor. No results are available at this time. The fertilization rates were very high as in 1988. The incubators will be removed in early April and analysed, and live fry will be shipped to the Ann Arbor laborabory, where they will be reared with the other experimental lots.

Future Directions

Future spawning and in situ incubation studies will depend upon the results of the studies that are currently underway. However, there is evidence that substantial spawning is occurring inshore around the Outlet Basin. A survey will be conducted in the fall of 1990 to examine additional and alternative traditional spawning sites that are more readily accessible during the severe weather conditions that occur in the fall. Salmon Island Bar, a traditional native lake trout spawning site east of Amherst Island, will receive special attention. Research projects that involve establishing and studying artificial spawning reefs, detecting and quantifying the effects of predation, and using otoliths to study interstitial water quality will be considered.

Nursery Habitat and Indigenous Juvenile Lake Trout - 1989 Study Update

J. M. Casselman and J. P. Dibbits

Background and Objectives

Young lake trout are usually not sampled very effectively in most routine netting studies because juvenile lake trout in naturally sustaining lake trout populations are not very active and are never very abundant. From an extensive literature review, it is apparent that juveniles (up to approximately 4 yr of age) are usually found in very deep water, below the midsummer depth distribution of the adults. In inland lakes, juveniles are found at 39 +/- 11.5 m (mean +/- 95% C.I.), whereas adults are found at 23 +/- 4.9 m. As would be expected, juvenile lake trout in the Great Lakes are found deeper (56 +/- 12.2 m), whereas the summer vertical distribution of the adults is 29 +/- 9.8 m (Casselman 1990a).

The purpose of this study is to sample the deepwater lake trout nursery refugium to determine species composition, abundance of potential predators, and environmental conditions. The deep St. Lawrence trench in the vicinity of Yorkshire Bar was chosen for intensive sampling with trawls and bottom-set fine-mesh gillnets that have successfully caught young indigenous lake trout in the deep water of inland lakes. This location was chosen because it contains the deepest water in the Outlet Basin (approximately 50 m) and falls within the depth range of typical Great Lakes juvenile habitat (44-68 m). As in 1987 and 1988, all lake trout caught in programs at Glenora and classified as unmarked were examined in detail to determine if they were indigenous.

Progress

Bottom-set, fine-mesh monofilament gillnets ranging in mesh size from 0.5, 0.75, 1 to 5 inches in 50-ft (15.24 m) panels were set in replicate at the 40 m (N = 4) and 50 m (N = 5) depth in the St. Lawrence trench southeast of Yorkshire Island in late August 1989. Deeper sampling (down to 70 m) was not done because of time constraints, and net-lifting problems prevented the deeper sampling that had been requested. No trawling was conducted in 1989.

Catches were extremely consistent and were composed mainly of lake trout and smelt, with a few lake whitefish and alewife. In total, 176 lake trout were caught. As in 1988, the deeper sets caught significantly smaller trout. Four (2.3%) of the lake trout had no external clip or hatchery mark. Fins of these fish were removed, dried, and examined in the laboratory in detail for variations in the normal size, shape and fin-ray counts. Snouts were removed and digested to see if nose tags were present. Otoliths and scales of the unmarked lake trout were removed and examined in detail later for characteristics that have been shown to separate indigenous lake trout from those of hatchery origin (Casselman 1990b, submitted for publication).

These procedures were initially developed on lake trout from inland lakes but were later tested on all Great Lakes stocks except Lake Ontario. The method has subsequently been tested successfully on several inland lake populations. Studies of Lake Michigan lake trout have been conducted for the Wisconsin Department of Natural Resources and the Great Lakes Fishery Commission. The most recent study using Lake Michigan samples from 1983 showed no evidence that significant numbers of indigenous lake trout were present in spawning groups that were examined.

A detailed examination of the otoliths of lake trout taken when this area was sampled in 1988 indicated that 66% of the clipped (hatchery) lake trout had otoliths that showed an anomalous, irregular, opaque nucleation which had been found to be typical of hatchery fish. This occurrence is the highest of any population studied to date. Similarly, stocked lake trout from the Outlet Basin showed a very prominent stocking check in their scales typical of fish of hatchery origin. None of the eight clipped fish in 1987 and 14 unclipped fish in 1988 showed any characteristics indicative of indigenous fish.

In addition to the four unclipped lake trout taken in this study, 31 unmarked lake trout were taken in other sampling programs at Glenora in 1989. The scales, otoliths, and fins of all these unmarked fish were analysed and were independently classified by each of the various methods as to origin. The results were combined to estimate the chance that any individual was indigenous (Fiset and Casselman, 1989). Two small unclipped lake trout were consistently classified as indigenous fish by all four methods. The characteristics in the otoliths and scales were distinctly indicative of native lake trout (chance these fish were indigenous--92% and 96%). Both fish were caught at Research Station 2 in the Outlet Basin. This station is in the vicinity of the Upper Gap adjacent to the mouth of the Bay of Quinte. The fish were taken in 30 m of water in 1.5-inch-mesh bottom-set gillnets. Although they were taken in deep water, it was not as deep as was expected from previously recorded depth-distributions of juvenile lake trout in the Great Lakes. It was, however, some of the deepest inshore water of the Outlet Basin and fell within the depth range (27-50 m) in which juveniles are found in inland lakes. Therefore, initial summer surveys of juveniles in Lake Ontario should especially consider the 27- to 60-m depth range. One fish taken on May 25 was 175 mm FL [TL = 183 mm] and weighed 58 g, K = 0.95 (TL); the other fish was taken on August 22, was 192 mm FL [TL = 202 mm] and 62.8 g, K = 0.76 (TL). Stomach analysis of both fish indicated that they were planktivorous. This is the first time since the demise of the native lake trout stock from Lake Ontario that naturally recruited juvenile lake trout have been reported for Lake Ontario. As a result of intensive stocking, it now appears that some naturally produced juvenile lake trout are present in the Outlet Basin, indicating that the rehabilitation plan for Lake Ontario has reached another important milestone. Although the numbers are not large, the fine-mesh gillnets used by Research and Assessment in the deeper portions of the Outlet Basin in 1989 caught 204 lake trout less than 250 mm FL. From these relative catch statistics, it is possible that 1% of the lake trout in the Outlet Basin that are less than 250 mm FL are indigenous.

Future Directions

It is recommended that: (1) More sampling, involving very fine-mesh gillnets, be done in deep water to assess more thoroughly the natural recruitment of juvenile lake trout. (2) The otoliths, scales, paired ventral and adipose fins, and snout be removed from all unmarked lake trout and all four be used independently to ascertain if the fish are of native or hatchery origin. (3) Surveys be conducted at spawning time inshore in the Outlet Basin to estimate the amount of spawning and the extent and determine if there are specific sites that could be contributing to this natural recruitment. (4) Midsummer surveys for indigenous juvenile lake trout should encompass at least the 27- to 60-m depth range, and a preliminary survey should be conducted in the deep trench inside the Upper Gap at the confluence of the Bay of Quinte and the Outlet Basin of Lake Ontario. (5) A system be developed so that the specially designed, fine-mesh, machine-hung, experimental gillnets that have consistently caught indigenous juvenile lake trout in inland lakes can be mechanically lifted and fished in deep water (30 m) of Lake Ontario.

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Research Project: Stock Identification Of Lake Ontario Lake Whitefish

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Lake Ontario Fisheries Unit, 1989 Annual Report, LOA 90.1 (Chapter 18)

Background and Objectives

There is considerable evidence that there are two different stocks of lake whitefish in the Outlet Basin of Lake Ontario and the Bay of Quinte. They have often been referred to as simply the "lake" and "bay" stocks.

In recent years, both of these stocks have shown a rather dramatic increase. This was first observed in the lake stock. However, in recent years, both have increased concurrently. Studies involving movement, year-class strength analysis, and electrophoresis suggest that lake whitefish from these two locations should be managed as distinct units. Various people, including commercial fishermen, who handle the fish regularly, have indicated that there are phenotypic differences between the two stocks. These are, however, subtle and not well enough defined to allow stock recognition during routine data collection. For this reason, a study was initiated to determine if calcified structures that are routinely collected and used in age assessment could be used to recognize and discriminate between the two stocks, especially when they are mixed. The "bay" and "lake" stocks appear to occur together in the Outlet Basin during the summer.

In addition, recent routine age interpretation from the scales of these two stocks of whitefish suggests that scale ages are neither consistent nor accurate enough to begin a detailed analysis of year-class strength of the species in the long-term research data sets. A study was initiated to test the validity of scale age determination techniques and to develop criteria to interpret age accurately and at the same time examine whether these calcified structures could be used routinely to discriminate between the two stocks.

Progress

In the fall of 1988, approximately 100 lake whitefish were collected by trapnet from the spawning run in the Bay of Quinte at the mouth of the Trent River. A similar number of fish were purchased from the commercial harvest from the spawning grounds on the lake shore south of Prince Edward County. The sample was collected randomly, although approximately equal numbers of males and females were included.

Scales and otoliths were collected from the fish, along with basic biological data. The scales were imprinted on cellulose acetate, and age was interpreted, using the routine procedures of the Glenora Fisheries Station.

Recently, a program using Fourier Series Analysis was converted from mainframe format to run on a microcomputer interfaced with a digitizer that is used in age-growth interpretation studies. This quantitative shape-analysis system is called SSHAPE, is menu-driven, and allows the digitization of the outline of an image and quantification of its shape by calculating the amplitudes and shift in phase angle for a specified number of harmonics.

There is reason to believe that Fourier Series Analysis of the shapes of both scales and otoliths of lake whitefish can provide a quick and easy technique for routine separation of the bay and lake stocks of whitefish, because Casselman et al. (1981) have shown that five stocks of lake whitefish from Lake Huron could be separated successfully by either scale or otolith shape.

Scale and otolith images for each fish from this data set have been digitized. Fourier Series Analysis was used to quantify the shape of each structure, and the amplitude and shift in phase angle for each of the first 20 harmonics were stored for subsequent analyses. Discriminant-function analysis will be used to examine stock identity and discreteness. Other biological data will be included in this analysis, especially age, since the shape of the structure varies with age.

Age is an important variable in this analysis. To examine the validity of age interpretation procedures, one otolith from each fish was embedded, transverse thin-sectioned, mounted on glass slides, ground, polished, and interpreted. At this stage, acetate replicas were made of the acid-etched, highly polished surface. The otolith sections and replicas were interpreted by two different experienced interpreters. At this point, it was realized from the differences in the results that it is especially difficult to recognize the first annulus in the otoliths of these whitefish. Some otolith measurements were made to help resolve the problem. However, it was concluded that additional criteria were needed to recognize and validate the first annulus in the otolith replicas of these whitefish.

Preliminary comparisons of the ages from the scales, otolith sections, and otolith replicas indicated that, as expected, the otolith replicas were much easier to interpret and provided more consistent results between interpreters than did the other two procedures. This method is especially reliable for very old fish. Several lake whitefish from the lake sample were independently and consistently interpreted as being 20 and 26 years old. Scales grossly underestimated the age of these particular lake whitefish. The results for the otolith sections and replicas were quite similar, whereas the scales underaged the older fish of both stocks even though the ages of the oldest fish were slightly different. "Lake" lake whitefish were generally older. The modal age was 9 as compared with 4 for the "bay" lake whitefish. There was strong evidence from the multiple interpretations that the year-classes congregating in these two spawning locations in 1988 were different. Generally, there were two pairs of strong year-classes in both stocks; 1979 and 1980 represented 33% of the lake sample, whereas the next two years, 1981 and 1982, represented 28% of the bay sample. This confirmed that in recent years, the lake stock showed a resurgence one to two years before the bay stock. The more recent 1984 and 1985 year-classes were strong in both stocks. They represented 48% of the bay stock and 26% of the lake stock. It appears that different factors affected the year-class strength in the late 1970s and early 1980s. However, when both stocks were at a relatively high level, similar factors may have influenced the stronger 1984 and 1985 year-classes.

Future Directions

The following recommendations are made. 1) A similar sample of fish and calcified structures should be taken in 1990 to help test the validity and refine age interpretation of these two stocks. 2) Otoliths from younger fish should be examined to study the location and to develop criteria for recognizing the first annulus in otolith replicas. 3) Large whitefish should be selectively sampled to obtain otoliths to examine historic year-class strength reflected in the oldest individuals in the population. 4) The quantitative shape analysis should be completed with the resulting models tested on the new samples that are collected in the fall of 1990. 5) Shape analysis should be conducted on a sample of otoliths and scales from lake whitefish taken in midsummer from the Outlet Basin to determine the proportion of these two stocks in this mixed-stock situation.

This stock discrimination technique has broad applications, because researchers working on cod in the North Atlantic have requested the software and are currently using it to examine stock discreteness among 18 major spawning groups of cod from Florida to Greenland.

The software developed to conduct Fourier Series Analysis for quantifying shape has applications in forensic science. It has been used in law-enforcement problems, most recently on Lake Huron. This problem involved species identification of a series of scaled, smoked fillets. It was suspected that the fillets were from an illegal species, rainbow trout. Scales of salmonids of known identity were digitized as reference material. The species included were lake trout, splake, rainbow trout, brown trout, Atlantic salmon, chinook salmon, coho salmon, and brook trout. The brook trout scale samples were provided by the Ontario Federation of Anglers and Hunters from the scale archive of the Big Fish Contest. The quantitative shape characteristics of these species were compared. along with sets of scales from the unknown samples. The Fourier variables were analysed with basic statistics. In addition, basic scale measurements and circuli counts were made and compared. When compared with all eight species, the unknowns most closely resembled rainbow trout. The variance explained by the first five harmonics, their amplitudes, and shift in phase angles confirmed that the unknown samples were not significantly different from rainbow trout and were significantly different from all other species of salmonids examined.

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Research Project: Discriminating Between Rainbow Trout Of Native And Hatchery Origin

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Background and Objectives

Assessment of rainbow trout stocks in Lake Ontario and its tributaries has been complicated because in some cases a large percentage of the fish are unmarked (unclipped). Although some stocked trout are inadvertently and even intentionally released unmarked, the exact identity and origin of these unmarked fish is usually unknown. Some may be indigenous. Stream studies have confirmed that there is natural recruitment of rainbow trout in tributaries of the Great Lakes, including those on the north shore of Lake Ontario (T. Kwain, pers. comm.). However, it is not possible to assess the contribution of this natural recruitment, since it has not been possible to separate indigenous rainbow trout from unmarked fish of hatchery origin.

A study conducted on lake trout has developed criteria for otoliths and scales that can be used to identify and discriminate between indigenous fish and those of hatchery origin (Casselman, 1990, submitted for publication). Very generally, native lake trout have otoliths that show concentric growth in the nucleus, and the first two annuli in the scales are relatively indistinct with no obvious check indicating a prominent transition in growth (stocking check). Otoliths of hatchery fish often have an amorphous opaque nucleation in the centre and prominent, translucent, even crystalline, mineral deposition outside the nucleus. Since otoliths of lake trout are usually normal when the fish leave the hatchery as yearlings, these anomalies appear to be associated with release and establishment in the natural environment.

Assessment personnel working on Lake Ontario asked Research to study the origin of unclipped rainbow trout and, if possible, to develop criteria from the scales or otoliths to separate indigenous fish from unmarked individuals of hatchery origin. Seelbach and Whelan (1988) have shown that scales can be used to separate hatchery and indigenous rainbow trout in Lake Michigan. Research began a systematic analysis of the morphological characteristics of the optical zonation in the otoliths and the extent, location, and conspicuousness of the checks in the scales. Special emphasis was placed on studying characteristics associated with scale and otolith growth and development during the first few years of life up to and shortly after the time of stocking.

Progress

The scales used in this study were supplied by Assessment and came from two general sources: one from creel census along the north shore of Lake Ontario and the other from spawning runs in three major streams (Credit, Ganaraska, and Wilmot). Only scales were available from the creel census (N = 166) whereas both scales and otoliths were available for the fish taken from the spawning runs (N = 59).

The scales were imprinted on cellulose acetate and were examined at approximately 40x magnification. To determine initially if there were any consistent differences in the scale patterns of hatchery fish, the scales of clipped rainbow trout were examined in detail. The otoliths of the clipped fish were also examined at the outset to ascertain if there were consistent characteristics in the surface morphology, in the opacity and translucency about the nucleus, and in the degree of translucency and width of the first few concentric translucent zones immediately outside the nucleus. Unfortunately, there were no otoliths or scales from truly indigenous fish to be used to develop specific criteria to contrast with fish of hatchery origin. The unclipped rainbow trout in the samples could have been from either source. The samples of scales and otoliths from unmarked fish were also examined systematically to determine if there were any consistent characteristics that contrasted the characteristics observed in the scales and otoliths of the clipped rainbow trout.

During this examination, all prominent checks on the scales were measured, ranked concerning their extent, location, and conspicuousness, and classified as annuli, pseudoannuli, partial annuli, or simply relatively indistinct checks. If a check associated with a prominent growth transition occurred, its conspicuousness was ranked and its location was measured. The abnormalities associated with non-concentric growth in the otolith were traced under a camera lucida and the translucency of the nucleus, the opacity of the tissue surrounding the nucleus, and the degree of translucency of the first distinct translucent zone were ranked. As a result of this systematic analysis, criteria were developed for both scales and otoliths of clipped rainbow trout. Some unclipped fish showed considerably different characteristics in both structures. These otoliths contained zonation that was distinctly regular and uniform, whereas the scales often showed a distinct check that delineated a prominent change from narrowly spaced, thin, fragmented, irregular circuli to widely spaced, thick, continuous, concentric circuli.

Otoliths of rainbow trout of hatchery origin had a prominent, irregular, translucent nucleus that extended from the origin of the otolith towards the anterior, through the first opaque zone. The first opaque zone was irregular in shape and had surface nucleation visible on the lateral that extended out to a prominent translucent zone which was usually visible around the entire otolith. In contrast, some unclipped fish had extremely concentric, regular spaced opaque and translucent zones about a small, concentric, translucent nucleus. Irregular translucency and prominent, opaque nucleation were not apparent about the origin on the lateral surface of these otoliths.

From this comparative examination, it is obvious that there are characteristics in both the scales and otoliths of Lake Ontario rainbow trout that can be used to separate hatchery fish from those of native origin.

To obtain preliminary results for the application of this technique, all samples were classified and ranked, independent of marking information as hatchery or native fish. The error rate in identifying marked fish as being of hatchery origin from scale characteristics was approximately 17%. When the classification of all unmarked fish was corrected for this error rate, 34% of the unmarked fish from the creel census were classified as indigenous. Scales from fish in the spawning run showed characteristics that were much more prominent. The error rate in identifying hatchery fish in these samples was only approximately half (8%) that of the samples from the creel census. When the classification of scales of unmarked rainbow trout from the spawning run were corrected for this error rate, 62% were identified as indigenous fish. Otoliths of marked rainbow trout from the spawning run were all classified correctly (error rate 0%). It was estimated from the otoliths that 60% of the unmarked rainbow trout in the spawning run were indigenous, results very similar to those obtained from the scales. From these samples, it was estimated that almost twice as many of the unmarked fish in the spawning run are indigenous as compared with unmarked fish from the creel census.

Future Directions

From this preliminary study, there is evidence that there are very specific and quantifiable characteristics in the otoliths and scales of rainbow trout that can be used to separate fish of native and hatchery origin. Additional research should be conducted and the criteria should be more thoroughly defined, quantified, and illustrated. To quantify these characteristics, the checks and zones in these scales and otoliths will be digitized and their locations and shapes analysed by using discriminant function analysis. It is necessary to obtain and include in the comparison a sample of truly indigenous rainbow trout. If these are not available from Lake Ontario, then another location in the Great Lakes, such as Lake Huron, could be used as long as the growth characteristics of the fish are similar to those of Lake Ontario stocks. To conduct a more complete study, a larger sample of scales and otoliths should be collected from both marked and unmarked rainbow trout from Lake Ontario, especially involving fish from spawning runs. The paired ventral and adipose fins of these fish should be removed so that regeneration can be examined more carefully and quantitatively under laboratory conditions.

References

CASSELMAN, J. M. Scale, otolith, and growth characteristics of juvenile lake trout--criteria for discriminating between indigenous and hatchery fish from the natural environment. (MS 1990, submitted for publication) 35 pages.

SEELBACH, P. W., AND G. E. WHELAN. 1988. Identification and contribution of wild and hatchery steelhead stocks in Lake Michigan tributaries. Transactions of the American Fisheries Society 117:444-451.

CORRECTIONS TO 1989 ANNUAL REPORT

CHAPTER 8 - 7, Table 3: Third and fourth column headings should read: "*No. Eggs With Embryos*" and "*No. Eyed Eggs*".

CHAPTER 8 - 8, Maturity: "From 1984 to 1988, a smaller percentage of 5 yr old Superior strain females were maturing each year (P.02, *Fig. 10*) and the age at onset of maturity was increasing (Fig. 3).

CHAPTER 8 - 8, Figure 9: FIG. 9(a) is the bottom figure and FIG. 9(b) is the top figure.

CHAPTER 9 - 4, Table 5: Brown Trout mean catches are *2.7, 8.0 and 4.9.*

CHAPTER 12 - 8, Fin clips show ... A proportion of rainbow trout attributed to Canadian stockings in the Central Region has increased from *2.2 - 3.7%* in 1987 (Stewart 1988), 4.4% in 1988 (Stewart and Savoie, 1989) to 8.5% in 1989 (Table 11).

CHAPTER 15 - 4, Table 2: Bullhead 3.05; 17.5; *81.56; 16.7* Gizzard Shad *0.55; 87.4; 43.53; 17.2* Table 3: Lake Trout *83.05; 9.7* White Sucker *62.85; 8.9; 74.92; 5.5* White Perch 5.23; 111.0; *48.05; 29.0*

CHAPTER 15 - 5, Table 4: Pumpkinseed *1.0; 244.9*